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Forthcoming Events.

SEPTEMBER 3-5.

Iron and Steel Institute:—Autumn meeting at the British Empire Exhibition.

SEPTEMBER 6.

Institute of British Foundrymen (Lancashire Branch):—Visit to Messrs. The Richmond Gas Stove & Meter Company, Limited.

SEPTEMBER 8.

Institute of Metals:—Annual meeting in London. "Recent Developments in Non-Ferrous Metallurgy in the United States." Paper by W. M. Corse.

SEPTEMBER 9.

Institute of Marine Engineers:—Ordinary meeting in London. "The Measurement of Pressure," Paper by J. Lawrence.

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN AND THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION.

Institute of British Foundrymen.

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Centrifugal Castings.

No metallurgical process of recent times has exhibited greater economical potentialities than the manufacture of castings by the centrifugal process, and we are convinced that this country has contributed more to the advance of the industry than any other country. In Great Britain the process is exploited by the Stanton Iron Works Company, the Sheepbridge-Stokes Centrifugal Castings Company; Stokes Castings, Limited; Centrifugal Castings Company; Thwaites Brothers, Limited; and the British Chuck and Piston Ring, Limited.

Metallurgically, the process has the advantages of the elimination of non-metallic inclusions, the reduction of ingotism and, in the case of cast iron, the more even distribution of fine grade graphite. The disadvantage shown is that of chill in the case of some metals and alloys. On the mechanical, yet still metallurgical side, is the difficulty of providing suitable moulds—a factor which will take much thought and experiment to overcome in the case of steel. One British firm has succeeded, so far as cast iron is concerned, by the provision of nickel chrome steel moulds. Once this question is finally disposed of, the potentialities of the process assume even greater importance. Mr. Cammen's proposition to cast sheet bars, described elsewhere in this issue, is one such phase. This development indicates that the process need no longer be confined to cylindrical objects, but has now been extended to include roughly rectangular ones. Harrow-points are a typical job that could be cast centrifugally, and is a case where the chilling would be an advantage. Cast-iron railings is another.

The most interesting aspect, however, is the manufacture of semi-finished steel products. McConway, of Pittsburgh, has tackled steel tyres; Cammen, in addition to sheet bars, envisages rails. Girders, channels, angles, flats, rounds, hexagons, all offer possibilities providing the centrifugal casting of the semi-finished product can be effected more cheaply than the combined pit and early rolling costs. A feature which offers a rapid solution to the difficulty of the moulds in the Cammen process is that there are fourteen in one machine. This allows of the rapid investigation of diverse materials. A good deal of empirical data is available from the glass bottle industry and the already established centrifugal casting processes.

As in most other modern processes, the economic applicability of the method is governed by the assurance of continuous large-scale orders for objects of similar shape. Whilst the new development is interesting and opens up a new field for thought, the original object of cylindrical shapes is by no means exhausted, and foundrymen should give intensive thought to the primary problem and the allied proposition of the construction of permanent moulds.

The centrifugal casting of steel is obviously more difficult than cast iron, because of its higher melting point, and the solution of this problem has a dual aspect. Primarily there is the provision of a suitable mould, and secondly, since there is no steel-making process analogous to the cupola, it means that there must be provided a large number of machines to deal with an intermittent output, or the machines must take but a portion of the production of several furnaces. Neither of these has a very strong practical appeal. The spinning of hollow billets for tube drawing and miners' drill steel is apparently still untouched by the inventor.

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

"Body" and "Liquidity."

To the Editor of The Foundry Trade Journal.

Sir,—I agree with Mr. Kent Smith that there is no interdependent or reciprocal connection between "body" and "liquidity."

The point I wished to make in my discussion of these interesting factors in steel metallurgy was that, from the arguments which I advanced, they would both seem to depend, mainly, on the amount of iron oxide in solution in the metal; the "body" decreasing with an increase of dissolved iron oxide, and the "liquidity," other factors being constant, increasing with an increase of dissolved iron oxide.

That the two qualities arise from the same cause is accidental. I do not attempt to marry the couple and make them one! It would be just as wrong as to say that steel, being spoilable by the heat of a blacksmith's fire, to melt steel by heat is a related matter.—Yours, etc.,

Victor Stobie.

Dunston-on-Tyne,
August 23, 1924.

Catalogues Received.

Pyrometers.—We have received from the Cambridge Instrument Company, Limited, 45, Grosvenor Place, London, S.W.1, a three-leaf folder describing a new series of dial thermometers stressing the point of ease of reading. Six standard patterns are described. These cover a range of from 20 deg. Fah. to 550 deg. Fah., in eight overlapping stages. For core-baking the one reading between 300 deg. Fah. and 550 deg. Fah. should prove a useful instrument.

Foundry Statistics.

In 1924, in the twelve months ending June 30, the United States exported 28,925 tons of cast iron pipes, and 9,491 tons of iron castings and 6,302 tons of steel castings.

For the first six months of this year France exported 57,006 metric tons of castings. To Britain they exported 311,547 metric tons of pig-iron.

Germany during the first half of this year exported 11,888 tons of cast-iron pipe, 3,865 tons of cast-iron rolls, and 31,758 tons of other castings.

Mr. W. M. Corse, consulting metallurgist to the International Nickel Company, of 1,901, Wyoming Avenue, Washington, D.C., is at present visiting Europe.

Councillor George Pickup, J.P., a partner in Pickup & Kelly, iron and brass founders, of Darwen, Lancashire, has declined the invitation of the local Town Council to remain in office as Mayor for another year.

Alderman F. J. West, C.B.E., who has accepted the invitation to become the next Lord Mayor of Manchester, is resigning his position as head of West's Gas Improvements, Limited, and the Derbyshire Silica Brick Company, in order to devote a maximum of time to his civic duties.

Mr. P. H. Griffin, of the Griffin Chilled Steel and Iron Company, of 27, William Street, New York, is at present visiting Europe. His process of making chilled railway-truck wheels is carried on under the general direction of Mons. Ramas at the Société Française Metallurgique (procédés Griffin) at Gorcy, Meurthe-et-Moselle, France. A considerable demand exists in France for the products of this process and, we understand, Mr. Griffin is desirous of extending operations in England. The production of "chilled steel" utilises scrap and employs a modified cupola for melting. Up to now, chilled "car wheels," as they are termed in America, have not found much favour amongst British railway engineers.

Company News.

Wilson Bros. Bobbin Company, Limited.—Dividend, 6 per cent. for year; previous year, 8 per cent.

Lancashire Dynamo & Motor Company, Limited.—Interim dividend of 2¾ per cent. on preference, no interim on ordinary.

Bolckow, Vaughan & Company, Limited.—Half-yearly dividend to June 30 on the preference shares of the company will not be paid.

Ferodo, Limited.—Final dividend of 15 per cent., making 20 per cent. for year, tax free, on ordinary; reserve, £15,000; forward, £7,779.

Leslie & Company (Birmingham), Limited, 19 and 20, Key Hill, Birmingham.—Capital £3,000 in £1 shares. Stamp and die tool makers, etc.

Banff Foundry & Engineering Company, Limited.—Capital £5,000 in £1 shares. Directors: A. Grant and R. W. Hutchison, 5, George Street, Banff.

G. Dikkers & Company (England), Limited, Effingham House, Arundel Street, Strand, London, W.C.2.—Capital £2,000 in £1 shares. Ironfounders.

Fairbairn Lawson Combe Barbour, Limited.—Interim dividend on preference at the rate of 5 per cent. per annum for the half-year to June 30.

Dixon & Corbitt and R. S. Newall & Company, Limited.—Net profit for 1923, £6,286; available, £8,502. Dividend, 5 per cent.; £502 carry forward.

Thos. Hill & Company, Limited, River Street, Derby.—Capital £1,000 in £1 shares. Engineers, metal and machinery merchants, etc. Directors: A. F. Baum and T. Hill.

John Hetherington & Sons, Limited.—Profit £21,405; brought in, £89,654. Final dividend of 6¾ per cent. on ordinary, less tax, making 10 per cent. for year; forward, £62,262.

Hartley & Sugden, Limited.—Profit, £10,473; brought forward, £2,167; available, £12,640; dividend, 5 per cent. on ordinary shares; to reserve £6,490; carry forward, £1,285.

Walter Scott, Limited.—Accounts show a disposable balance of £26,316. After meeting debenture interest, directors' fees and special reserve contribution, £4,285 is to be carried forward.

Scattergood & Johnson, Limited, 7, Cookridge Street, Leeds.—Capital £10,000 in £1 shares (2,000 5 per cent. cumulative preference and 8,000 ordinary). Engineers. Director: B. P. Scattergood.

Edward S. Johnson & Company, Limited, 126, Pilgrim Street, Newcastle.—Capital £2,500 in £1 shares. Iron and steel merchants, etc. Directors: E. S. Johnson (chairman and managing), H. S. Johnson and A. W. Johnson. Secretary: H. S. Johnson.

Contracts Open.

Johannesburg, September 10.—250 steel poles, for the Municipal Council of Johannesburg. The Department of Overseas Trade.

Chorley, September 6.—Steel work, for the Lancashire County Council. Mr. W. H. Schofield, county surveyor and bridgemaster.

Warrington, September 1.—140 lineal yards of cast-iron railings, for the Cemetery Committee. The Borough Surveyor, Town Hall, Warrington.

Buenos Aires, October 27.—Twenty-five steam travelling cranes and one stationary electric crane, for the Ministry of Public Works. The Department of Overseas Trade.

Hayes, Middlesex, September 1.—About 1,260 yards of 6-in. cast-iron rising, for the U.D.C. Mr. D. C. Fidler, engineer and surveyor, Town Hall, Hayes, Middlesex.

London, E.C., September 1.—Steel material, for the Bengal & North-Western Railway Company, Limited, and the Rohilkund & Kumaon Railway Company, Limited. Mr. E. A. Neville, managing director, secretary, 237, Gresham House, Old Broad Street, London, E.C.2. (Fee, 10s., non-returnable.)

London, E.C., September 1.—One 500-ton elevated water tank; 17 miles of 6-in. mild steel dipped pipe with fittings; 13 6-in. c.s. gate valves; 2,565 ft. 10-in. c.i. pipe; 5,157 ft. 8-in. c.i. pipe; 33,399 ft. 2-in. c.i. pipe; 14,436 ft. 6-in. c.i. pipe; with all accessories, all for the Public Works Department of the Sudan Government.

Mr. Robert Ronceray, the son of Mr. E. V. Ronceray, the well-known French foundryman, sailed last Thursday for the United States of America, where he proposes remaining for a few years. First of all, he is visiting Mr. H. M. Lane, of Detroit. Mr. Ronceray, junior, is well known in the Birmingham area, where he spent some time in the Soho foundries of Messrs. W. & T. Avery, Limited.

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The Furnace Industry.

By A. J. Smith.

Paradoxical as it may seem, it is strictly true that the trade in industrial furnaces which in constructional detail could hardly be simpler makes the most demand for technical skill. It is, however, in the applications of such apparatus and consideration of the special conditions governing each process for which it is utilised that the greatest call is made upon the experience of the manufacturer, and this probably to a greater extent than in any other industry. The daily post of the average furnace manufacturer brings a collection of problems, the elucidation of which requires an intimate acquaintance with numerous trades and the processes involved. Precisely in proportion as this knowledge, supported by adequate records, is possessed by the maker, will the success of the furnace be measured.

Even the humdrum and everyday work of quoting for and installing a simple type of crucible furnace calls for as wide an experience of the foundry trade as is possessed by many a foundry superintendent, necessitating as it does knowledge of the melting ratios of all kinds of metal with different methods of firing, labour costs, crucible charges, melting losses and something more than a superficial idea of metallurgy. Then, to keep the furnaceman's faculties from rusting there are the frequent large inquiries, such as those which call for the installation of a complete brass or iron foundry, with the output of each individual piece of apparatus and the usual guarantees given as to output and consumption figures. Or, to take another type of furnace of very simple construction, such as an oven or a muffle, the efficient handling of this trade involves a thorough knowledge of the different heat-treating processes for which it may have to be utilised.

Considering the importance of an accurate knowledge of fuel consumptions in any industry, quite apart from the very special interest which a furnace manufacturer has in this subject, it is strange that some standard form has not yet come into general use for the purpose of recording both consumption and output figures on such lines as would enable different results to be readily compared. The following is one form of summary which has proved its worth in dealing with a collection of such data extending over twelve years:—(1) Process (metal to be treated); (2) make of furnace; (3) method of firing; (4) air pressure; (5) consumption; (6) output; (7) sundry data; (8) remarks, including place of installation and date.

When data are thus recorded, it is an easy matter to find any figure which may be wanted, even if the total number of records runs into thousands, as in the author's case. A very effective classification is to divide the records into a couple of classes, the first relating to "melting" processes and the second to "heat-treating operations," while the requirements of a furnace manufacturer would probably demand a third class which would be devoted to the fuel consumptions of different types of furnace when running without load at different temperatures. Then, to further facilitate the work of reference, each of the foregoing divisions could be started with the records relating to the highest temperatures and following on with different processes in accordance with the gradually-decreasing temperatures required. For instance, in the "melting" classification a start might be made with the records dealing with steel-melting, working on gradually with the other metals according to their temperature of fusion, down to tin and lead.

Cast-iron Melting Pot for Lead.

Probably one of the simplest appliances made in the furnace trade is a cast-iron melting pot for lead; yet the marketing of even this simple appliance means that its maker must have studied the requirements of such complicated machines in the printing trade as the linotype and monotype composing machines, their requirements in the way of feed, the temperature of the metal, and the control thereof; while in a larger field he is called upon to adapt the same apparatus to the needs of the modern lead press for the production of lead pipes and cable work. With variations of the same simple apparatus, he has to provide for the tinning of wire of all gauges, for tinning articles which can be dipped, for galvanising, for the recovery of metal from dross and a host of similar applications. As far as lead is concerned, gas is an ideal fuel and a cheap fuel; but few people realise how cheap it can be when used under a well-designed furnace. The following are two examples of actual practice in this line:—(1) A 3-ton melting pot, usually worked with 2¼ tons of lead and fired by coal consumes 2,464 lbs. per week of 52 hrs., the fuel used per ton of lead melted being 158 lbs., and the metal tapped and replaced per week, 34,944 lbs. (2) With a similar furnace, but fired with town gas, with air-blast burners, the consumption of gas per week is 8,000 cub. ft.; per ton of lead melted 200 cub. ft.; and the lead melted per week, 40 tons.

Furnace Conversion Problems.

The most difficult, and at the same time the most fascinating branch of the furnace trade, is undoubtedly the consulting work which is involved when a firm makes a speciality of supplying either oil or gas burners separately for the conversion of existing furnaces. There is a large field for the conversion of solid-fuel furnaces either to oil or gas-firing whenever it is possible to prove any economy from the change-over; but here, as in many other cases, the profit is usually in inverse ratio to the work and the experience which is called for, and it is probable that if the truth were known, most makers find this class of work unprofitable. Naturally, when a conversion is contemplated, it is only human nature for the prospective customer when stating his existing fuel costs to give these rather on the economical side, so that from the outset the burner manufacturer has a very keen figure to beat when he wishes to prove a saving. Again, with the great majority of burners, it is difficult at first sight to justify a price greater than some £2 or £3 for the material involved, yet in the preliminary negotiation stages of a furnace "conversion" a burner manufacturer has quite frequently to make a closer study of the conditions and of the details of the existing furnace than the original maker did, besides having to support his quotation for the burners with a guarantee of performance as against the existing method of firing.

Many buyers ridicule the prices which are quoted for simple gas and oil burners, but ignore the fact that they would not dream of considering a quotation for such burners (far less placing an order for one) without detailed drawings and advice respecting their application, which information, if obtained from a properly-qualified consultant, would cost many times the sum quoted for the burners. In spite of these drawbacks, however, a number of makers of burners contrive to carry on a rather unremunerative trade to the general benefit of industry and the economising of fuel resources. One of the most interesting fields for the application of burners (particularly oil) is undoubtedly that offered by the large furnaces used in the shipbuilding industry, both for the heating of frames as well as for plates for bending. The following figures give some results in this connection with solid fuel, obtained in the yard of a well-known shipbuilding firm in Northern Europe, which show that here is an excellent opening for oil fuel and great possible economies:—The furnace is designed for frame-heating and measures 40 ft. × 2 ft. 3 in. × 1 ft. 7 in. When heating steel angles, and firing with coal, with slight air pressure, the consumption of fuel per day of 10 hrs., including heating up, is 26 cwts.; the amount of coal used per ton of output is 10 cwts., and the weight of angles heated per day of 10 hrs. is 50 cwts., whereas a furnace of exactly the same dimensions and used for precisely the same work in an English yard fitted with oil-fuel burners by an English maker worked with an average consumption of 12 galls. per hr.

Furnaces for Case-hardening.

A very interesting metallurgical process for the application of either gas or oil fuel is case-

hardening. Hitherto, although both fuels have been largely adopted for this work in competition with solid-fuel furnaces, the selection of gaseous or liquid fuel has almost invariably been due to the advantages they offer for exact temperature control, as authentic information as to fuel consumptions compared with output has been almost unobtainable with these latter, though a certain number of estimated figures of varying degrees of probability have been published from time to time. The following data will enable a very close idea to be formed of the cost of such work by gas. The figures have the advantage of being actual results, and though they were obtained in an economical type of furnace, the particular run on which they were recorded was just an ordinary odd case-hardening job going through the shop, there being no attempt made to obtain any record economy. The figures are dissected to give the consumption per hour, so that any prospective user can calculate the consumption in accordance with the depth of case required, which latter naturally varies considerably with different classes of parts. The results are, of course, quoted on the gross weight of the furnace charge, viz., boxes, carburising reagent and parts. The carburising furnace was fired with town gas, under two or three inches air pressure, and was employed in heating automobile steel gear wheels. The consumption of gas per lb. of charge to raise furnace and charge from cold to 900 deg. C. was 1.29 cub. ft., while the gas per lb. of charge required to maintain the charge at this temperature was as follows (in cub. ft.):—1st hr., 0.38; 2nd, 0.42; 3rd, 0.38; 4th, 0.42; 5th, 0.49; 6th, 0.49; 7th, 0.45; 8th, 0.45; total, 4.77 cub. ft.

Annealing.

Another highly successful result which deserves to rank with the best achievements of furnace work was the application of gas to heavy annealing work on a more economical scale than anything that had been before attempted. Though the figures are a few years old, they are still deserving of quotation, as it would be difficult to improve upon them even now. Though the process was known in the district as annealing, it would be better described as normalising, consisting as it did of raising the charge to about 920 deg. C. and withdrawing immediately. Town gas, under slight fan air pressure, was used as fuel, the charge consisting of steel castings. The consumption of gas per lb. of charge to raise the furnace and charge to 920 deg. C. was, in the case of No. 1 charge, 2.13 cub. ft.; No. 2 charge, 2.02 cub. ft.; and No. 3 charge, 1.54 cub. ft. In the case of the first heat, it should be mentioned that the furnace was warm from the previous day's work. These three runs gave the excellent results of 4,886 cub. ft., 4,528 cub. ft. and 3,460 cub. ft. per ton of castings heated respectively, the loads varying from 900 to about 2,000 lbs.

It may be thought from the few examples quoted that the furnace industry has no further heights to climb, or no further problems to solve. It is an industry, after all, which has still considerable progress to make before it reaches the efficiency and the standardisation of the boiler trade, for instance; but there are welcome signs of late that it is no longer generally treated as the Cinderella of all the other professions, and if the greater attention now being devoted to fuel economy in all parts of the world has for indirect result the attraction to the furnace industry of scientific and experienced helpers such as have in the past shown a disposition to turn chiefly to the mechanical and electrical branches of engineering, then before many years are out we may expect a great advance upon our present methods of heating.

British Association.—The annual meeting of the British Association for the Advancement of Science was held in Toronto, the presidential address being delivered by Major-General Sir David Bruce. The delegates were formally received by Mr. Ferguson, the Premier, and other members of the Ontario Government. The Council of the Association ratified the appointment of Professor Horace Lamb, D.Sc., F.R.S., lately Professor of Mathematics at Manchester University, as President for 1925. The next annual meeting of the Association will be held at Southampton.

Medium-Carbon High-Manganese Steels.

R.D. Report No. 61 (issued through the Stationery Office) by the Research Department, Woolwich, deals with the properties of medium-carbon steels with high-manganese content.

The five steels included in the present investigation were made by the crucible process; the ingots were reheated and forged into bars 2 in. by ¾ in. section. The carbon percentage was from 0.36 to 0.39 and the steel of maximum manganese content contained 5.25 per cent. manganese. This steel could be forged with difficulty, but the surface was very imperfect and showed numerous cracks. It was difficult to obtain this steel in anything but a martensitic condition and the manganese content was evidently much too high for steel for structural purposes. The steel with highest manganese content on which a complete series of tests was made contained 2.86 per cent. of manganese. A number of surface cracks were observed in this steel and this manganese content appeared to be near the limit of useful composition.

The bars were of the following compositions:—

—	A.	B.	C.	D.	E.
	%	%	%	%	%
C ..	0.37	0.39	0.36	0.39	0.39
Si. ..	0.12	0.11	0.09	0.24	0.43
Mn. ..	0.25	1.12	2.24	2.86	5.25
S. ..	0.042	0.035	0.027	0.031	0.054
P ..	0.023	0.025	0.025	0.025	0.034
Ni. ..	0.07	nil.	nil.	nil.	0.04
Cr. ..	0.05	0.003	0.003	0.04	0.17

Heating and cooling curves were taken by the inverse-rate method of samples of the four steels after normalising, temperatures being measured by means of a platinum platinum-rhodium thermocouple and Carpenter-Stansfield potentiometer, and time intervals noted for every 0.025 millivolt, equivalent to about 2½ deg. C. The rate of heating employed was about 9 deg. C. per minute. Cooling curves were taken from 800 deg. C. and from 900 deg. C.

The conclusions arrived at were as follows:—

The critical points Ac_1 and Ar_1 are lowered by the presence of increasing amounts of manganese. Ac_3 and Ar_3 are lowered until they merge into Ac_1 and Ar_1 respectively. The presence of manganese tends to prevent the separation of ferrite and pearlite on cooling. The slowest permissible rate of cooling through the critical range to produce hardening and to suppress the separation of ferrite is much slower than that permissible for carbon steels. An increase in the initial temperature has little effect on the position of Ar_1 or on the hardness of the treated steel.

After oil-hardening and tempering at 650 deg. C. all the mechanical properties of a 0.4 per cent. carbon steel are improved by the presence of about 2 per cent. manganese. The improvement in properties is still maintained with 2.86 per cent. of manganese, but the additional manganese shows no advantage and may introduce difficulties in forging.

The steels with high manganese content are extremely liable to show temper-brittleness when slow rates of cooling after tempering are employed, but this may be avoided by suitable treatment. If good impact figures are to be secured, the cooling from the tempering temperature must never be slower than in air, and as the steels harden when quenched or quickly cooled from temperatures considerably below the beginning of Ac_1 as usually determined, a tempering temperature higher than 660 deg. C. should be avoided.

For many purposes for which it is desired to replace carbon-steel forgings by steels of greater strength the following composition may be suggested: Carbon, 0.35 to 0.40 per cent.; manganese, 1.8 to 2.2 per cent. Oil hardened from 800 deg. to 850 deg. C. Tempered from 610 to 650 deg. C. Cooled in air, oil or water.

Newfoundland Iron Ores.—British interests have acquired iron-ore deposits on the western side of Bell Island, Newfoundland, adjoining those of the British Empire Steel Corporation. A Montreal firm is engaged on the preliminary engineering work, and the ore is to be shipped to Great Britain.

A European View of the Malleable Question.

By T. Levoz, Auxonne, Cote d'Or, France.

The position of the malleable castings industry on the Continent of Europe has been considered at length at the Liège and Paris Congresses. The following passages embody the principal opinions expressed:—

"The first aim should be to interest all our French, British and Belgian confrères in the institution of systematic experiments, which should all be carried out in a uniform manner, so that they may be compared and the results intercommunicated.

"Permanent intercourse also should be maintained with our American confrères, and steps should be taken to insure the regular exchange of communications between the various associations.

"The second aim should be to interest the leading French, British and Belgian scientists in the investigation of the laws governing the manufacture of malleable iron, chiefly in regard to the effect of the silicon and that of the sulphur, on the condition of the carbon both at the two stages and on graphitisation of the carbon.

"In this way we shall attain the position long ago reached by our American confrères; that is to say, we shall be able to compete successfully with cast steel both as regards quality and price, thus preventing the disappearance of an industry which was formerly flourishing, but which is declining because European foundrymen work neither scientifically nor economically and are lacking in co-operation.

"Before the war the average cost price of an American manufacturer of malleable iron turning out agricultural machinery castings was 25 centimes per kilogram (about 2½d. per pound). Making all due allowances, there is no reason why we should not attain the same results."

Since then the Belgian and French technical foundry associations have formed a special commission for the purpose of carrying into effect the wishes first expressed at Liège.

Special attention has been excited by the exceptional results obtained by American foundrymen as regards the quality of the metal which, it appears, ordinarily shows the following mechanical characteristics:—Tensile strength, 19 to 31 tons per sq. in., and elongation 5 to 25 per cent. on 2 in., as compared with 19 to 25 tons and 2 to 4 per cent. in European practice. Here there is a wide gap, and, in order to bridge it, it is not enough merely to agree to establish uniform methods of experiment. What is required is an agreement to establish a single mode or method of production capable of supplying a metal suitable for the manufacture of good test pieces corresponding in structure to castings usually required in malleable iron.

What is a Suitable Metal?

Considering only the production of the metal which is the starting point of all manufactured castings, for when the metal is suitable three-fourths of the work of successful casting has been done. What, then, is to be understood by "suitable" metal? In general foundry practice (ordinary cast-iron, malleable cast-iron, or cast-steel), suitable metal is understood to be that which when cast flows over the sand on contact with it without attacking the organic matter. It is, of course, understood that the metal must combine the mechanical conditions and characteristics required. In order that the metal shall flow over the sand, its iron oxides must previously be reduced, and, if they are not reduced completely, it is preferable that they should be in the ferric rather than the ferrous state.

Many foundrymen are imbued with the idea that a metal cast too hot prevents the scraping of the sand on contact, but this is a mistake.

Of course, apart from the question of pipes and shrinkages, a perfectly deoxidised metal may be cast at maximum temperatures without attacking the organic matter of the sands generally employed in foundries—for ordinary cast-iron, mallable iron or cast-steel. The error is chiefly noticeable among founders of cast-steel, who often regard a dazzling metal as being too hot, even when it is greatly superoxidised, sometimes to the point of solidifying almost instantaneously when it is poured into the ladle.

The purpose of these remarks is merely to point out to founders of malleable iron that their interest is not only to study the part played by the carbon, silicon, manganese, sulphur and phosphorus, and that they have invariably neglected the part played by the principal factor—the iron oxide—which is the source of all their troubles and disappointments.

It is, in fact, the greater or less degree of oxidation of the iron that governs the temperature of the bath and, consequently, its composition.

Generally, whether it is a question of ordinary cast-iron, of malleable iron, or of cast-steel, in which the oxidation of the iron plays the most important part, it is necessary to have the initial metal at the maximum temperature so as to facilitate all the reactions necessarily arising from the presence, in larger or smaller quantities, of the ferrous or ferric oxides.

Now the former absorbs heat calories in order to be reduced in presence of the carbon, while the latter release them. This is why it was stated earlier in the Paper that it was preferable for the unreduced oxides in the metal to be in the ferric state.

It is easy to determine the presence of either of these oxides in liquid metal containing only iron and carbon, with a minimum of silicon and manganese.

Metal containing ferrous oxides boils violently in presence of carbon and liberates graphitic carbon at the moment of solidification, because all boiling causes cooling.

An examination of the worn rails on the P.L.M. tracks shows them to be full of blisters flattened out at the rolling mills. These blisters contain graphite and unreduced ferrous oxides. This is a striking example of cooling produced by boiling—ferrous oxides and carbon.

Selection of the Furnace.

To obviate this capital defect in the production of iron for malleable—a defect essentially of a practical nature—it is necessary that the first stage metal should be produced in apparatus providing maximum temperatures without the formation of ferrous oxides.

Foundrymen have available the crucible which was the first system of manufacture employed. It requires mixtures of good quality, and as the materials composing these are not exempt from rust and ferrous oxides are developed during fusion. To remedy the bad effect so produced the temperature of the furnace must be increased. This causes an excessive consumption of coke or coal, the result of which is a prohibitive cost of production.

The cupola furnace, which is mostly used, is the producer *par excellence* of ferrous oxides. It is a barbarous principle of melting, especially for the production of iron for malleable castings. To be able to cast the metal at all suitably, maximum temperatures must be obtained; the consumption of coke must be increased, as must also the silicon content. Hence the common practice of forcing the silicon addition in order to be able to make exceedingly thin castings.

The reverberatory furnace undoubtedly is the apparatus which least occasions the formation of ferrous oxides. However, it also is at the mercy of rusty materials and of other oxidising tendencies. If the Americans employ it with success in producing malleable iron of great elongation and strength, this is because they have succeeded by practical methods in obviating the formation of ferrous oxides by effecting the melting in a carbon monoxide atmosphere. Unfortunately, the employment of reverberatory furnaces is practicable only for mass production, and the con-

sumption of malleable castings has developed less in Europe than in America.

If European foundrymen had at their disposal a cupola obviating oxidation of the iron it is evident that such an apparatus would be the ideal method of producing malleable iron, subject to the condition, however, that it should effect fusion at the highest possible temperature.

Four years ago, in the "Fonderie Moderne," the writer drew attention in this connection to a small cupola with two tuyeres placed at different heights, with which he had obtained good results in a malleable-iron foundry in Belgium.

Melting by gas is less to be recommended, because it is almost indispensable to produce oxidising flames in order to secure the high temperatures required. In this connection it would be preferable to effect melting by the pulverised coal system, provided regenerators capable of heating the air of combustion to over 600 deg. Cent. are employed.

This applies also to the use of heavy oils, and in this case it is also necessary and indispensable to have a furnace specially arranged for an adequate distribution of the heat without oxidising the iron.

Electric Furnace Experiments.

The converter and the electric furnace remain. The latter, when employed as a melting apparatus, is also at the mercy of the pig-iron, scrap or other rusty waste; the operation must be carried to the point of complete deoxidation, and even at this point it is difficult to obtain uniform carburisation.

Recently the author made an experiment to see to what extent an electrically melted metal obtained from highly oxidised scrap, and containing also 25 to 30 per cent. of turnings agglomerated by the oxidation of the atmosphere, could be carburised and poured. Notwithstanding the fact that the slag was of suitable composition and the temperature raised to the extreme limit, uniform carburisation could not be obtained, and the metal, which appeared hot while in the furnace, solidified on being poured into the ladle because it still contained ferrous oxides which, in spite of everything, had not been reduced.

The only method of producing malleable iron electrically of uniform quality is by starting with scrap or a mixture of scrap and pig in a coke- or coal-fired furnace. The metal thus obtained is poured into a closed electric furnace, where it is finished, but for this purpose a powerful and cheap supply of electricity must be available. One foundry in the Hautes-Pyrenees, however, to which the writer is adviser, works on this system and obtains excellent results. It even provides foundrymen with pig-iron produced by this method, which, when remelted in cupola, crucibles or other furnaces, gives better results than blast-furnace pig, because it contains a minimum of graphitic carbon and a minimum of sulphur.

The German Method.

In the author's opinion, the only method of competing successfully with cast steel in Europe is to produce malleable iron on the same system as cast steel. The Germans, who have long specialised in the manufacture of cast steels and malleable iron, clearly recognised this, and since 1905 they have been making malleable by melting hematite pig in the cupola, afterward transferring it to the Bessemer converter in a liquid state in order to desiliconise it and pour into the moulds a metal which is merely carburised.

Three Germans introduced this method of manufacture into France with some success. This was at Colombier Fontaine, Doubs, about 1911. They did not succeed, however, in competing against cast steel, which they were obliged to produce also to supply the requirements of their clients. This was because this process was far from perfect.

As a result of the sequestration of this establishment shortly after the declaration of war (January, 1915) the writer leased the factory, and was thus in a position to acquaint himself with the quality of the metal produced.

It was far from suitable for the uniform production of good malleable iron. A sample was taken from the numerous gates found in the works and analysed, its composition being as follows:—C.C., 2.80; Gr.C., 0.50; Mn., 0.30; Si., 0.80; S., 0.06; and P., 0.09 per cent.

The ordinary bottom-blown Bessemer converter is not at all suitable for this kind of work, as it produces ferrous oxides while it is desiliconising the metal. The result is that the white pig bath is obtained too cold, which causes the formation of graphitic carbon at the moment of solidification.

Without even trying this process, the writer decided not to employ it. In this he was well inspired, for he found that the moulders who had formerly worked with the Germans ran like hares to fill the moulds placed at a maximum distance of 50 metres from the converters, although the metal was much too hot and fluid.

When asked the reason for this, they replied that when the Germans were there they were always made to hurry to cast the malleable iron, "otherwise they would not have produced a good casting."

If from time to time a good casting was produced this was owing to the metal bath in the cupola having been overheated.

Modified Method.

In 1915 the author started working scrap metal in the cupola, transferring it by means of a ladle suspended from the crane to a side-blown converter with D-shaped section, which had been installed by the Germans for the manufacture of cast steel. According to the men who had worked with the Germans, the metal we were producing was much hotter and more fluid. It was no longer necessary for them to scurry like hares to fill the moulds. They found also that we turned out few spoiled castings, whereas the Germans used to have 20 to 30 per cent.

The composition of the metal delivered from the converter was as follows:—C.C., 2.34; Gr.C., 0.2; Mn., 0.44; Si., 0.75; S., 0.1; and P., 0.08 per cent.

The higher sulphur content was due to the quality of the coke used during the war. The Germans used coke which contained less than 10 per cent. of ash and little or no sulphur. However, when the metal placed in the converter was too cold or when, for any other reason, the desiliconisation was accompanied by the formation of ferrous oxides, violent boiling took place as the metal flowed into the ladles, and the slag, which was extremely fluid, was carried into the moulds along with the metal. It was then necessary to put a small addition of aluminium in the ladles to calm the bath and obviate blow holes as much as possible.

Fractures of the annealed castings then showed a black structure similar to American castings. The castings were, however, exceedingly malleable, and they bent even better than those having a granular structure.

The mechanical tests of this metal gave the following results:—Tensile strength, 22 tons per sq. in.; elongation, 5 per cent. on 4 in.

Its chemical composition was:—C.C., 0.100; Gr.C., 1.200; Mn., 0.330; S., 0.101; P., 0.082; and Si., 0.987 per cent.

The same metal without aluminium addition had a granular structure, from which it may be deduced that the presence of the aluminium for the purpose of reducing the ferrous oxides immediately before solidification favoured the formation of hardening carbon or secondary graphite.

At this time it seemed that in order to obtain a more uniform metal the metal from the converter ought to be passed into a furnace heated to 1,500 deg. Cent., either by the gases or by heavy oils or electricity, and that it ought to have a small admixture of metal taken from the cupola.

A French Triplex Process.

In 1915 the author filed a patent in France for this process, and it appears that about the same time W. G. Kranz took out a similar patent in America for a "triplex process for making electric-furnace malleable-castings." The writer subsequently recognised that it was undesirable to reintroduce metal produced by the cupola, which favours the formation of graphite at the moment of solidification. The converter was installed with cylindrical crucible and tuyeres arranged tangentially to a circle of fixed diameter. A hotter and more liquid metal was obtained, because ferric

oxides were formed at the surface of the metal bath, and there stimulated the desiliconisation and, to a certain extent, the decarburisation, while maintaining the bath at the necessary temperature for casting without any aluminium addition.

When the operation is carried out normally in this converter the reddish vapours surrounding the flame do not appear until after desiliconisation and at the very beginning of decarburisation, increasing in proportion as the latter advances. The vapour ought not to cease on the first break through of the flame; it ought to continue until the second break and issue abundantly at the end of the blow.

If the reddish vapour is plentiful at the outset of the operation and diminishes or ceases on the first break through of the flame, ending with a rather bluish vapour, this indicates that the operation has not been effected normally.

In the first case, the adjustment for obtaining the malleable iron has been well determined, while in the second case it has been faulty, the result being variations in the quality of the metal. It then occurred to the writer to pass this metal, still taken in a very hot and fluid state, into a furnace heated to 1,550 deg. Cent., either by the gases, heavy oils or pulverised coal, but preferably by electricity, merely for the purpose of deoxidising, desulphurising and regularising the carbon, silicon and manganese contents.

Under the blowing conditions in the first case there is formation of ferric oxides which obviate the ebullitions which are so detrimental to obtaining suitable metal, and under these conditions the operation of adjustment in the furnace is easily effected.

In the second case ferrous oxides are formed, causing ebullitions and rendering the final operation of the furnace more complicated. It is necessary to overheat the metal bath in order to bring about a really effective reduction.

It was after coming to these conclusions that the author finally took out a French patent on this method of manufacture. A British patent also has been granted.

In order to work this triplex process accurately, and obtain the metal desired, it is essential that the following apparatus should be employed:—(1) A cupola with combustion zone distinctly separated from the zone of fusion in which only reducing gases circulate. (2) A side-blown converter which evacuates the slag as fast as it is formed, insuring the formation of ferric oxides which secure the fluidity of the metal for the purpose of preventing the formation of graphitic carbon on solidification. (3) An electric furnace which insures the proper distribution of heat with a minimum expenditure of electric power; or a heavy oil furnace, if electric power is not available.

Character of the Metal.

The average composition of the metal obtained is as follows:—C.C., 2.30; Gr.C., traces; Mn., 0.30; Si., 0.40; S., 0.03; and P., 0.05 per cent.

This metal, being obtained very hot and free from oxides, flows over the sand and produces castings which look clean and are without the defects usually found in ordinary malleable castings. It is noteworthy that castings of the most complicated form may be left to cool in the moulds with little risk of dents, cracks, flaws, fractures or other defects. The constant use of a reheating furnace, always alight to take the castings which are still red when stripped, is thus obviated.

No distinction is made in the silicon content whether thick or thin castings are made, which enables a metal only slightly charged with graphitic carbon to be obtained; and in view of the absence of oxides the latter is distributed uniformly throughout the mass in a pulverulent state, preventing the formation of cavities which cause breakages of continuity and are destructive of elongation and resistance.

The annealed metal has the following composition:—Gr.C. (disseminated throughout the mass in the pulverulent state), 0.90; Mn., 0.25; Si., 0.40; S., 0.03; and P., 0.05 per cent.

This metal gave the following results under mechanical tests:—Tensile strength, 25.4 tons per sq. in.; elongation, 15 per cent. measured over 4 in.

A metal obtained by the same process is capable of producing all castings, whether thick or thin, with the following composition:—C.C., 2.00; Mn., 0.40; Si., 0.25; S., 0.05; and P., 0.03 per cent.

Reheated for 72 hours in a furnace at a constant temperature of 850 deg. Cent. without ores the results under mechanical tests were:—Tensile strength, 38.1 tons per sq. in.; elongation, 12 per cent. on 4 in.

In this process the pig destined for conversion was obtained synthetically in the non-oxidising cupola by the intimate mixture of 10 to 12 per cent. of ferro-silicon and miscellaneous scrap and waste.

The metal produced by this process possesses mechanical qualities almost equal to those of cast steel, but with the important difference that the castings are much cleaner in appearance.

These cast steels, it is true, give the following results under mechanical tests:—Tensile strength, 25 to 32 tons and more per sq. in.; elongation, 15, 20, 25, and even 30 per cent. on 4 in. The castings do not always have such a good appearance, and they may harbour hidden defects arising from bad manufacture. A manufacturer who employs the triplex process can produce simultaneously either direct cast steel, indirect cast steel, malleable iron or special steel or tempered castings.

[The views expressed by the author, in regard to the effect of ferrous and ferric oxides, are extremely interesting when studied in conjunction with the controversy on "Body and Liquidity" which has been running in this journal during the last few weeks.—EDITOR.]

Gases in Malleable Cast Iron.

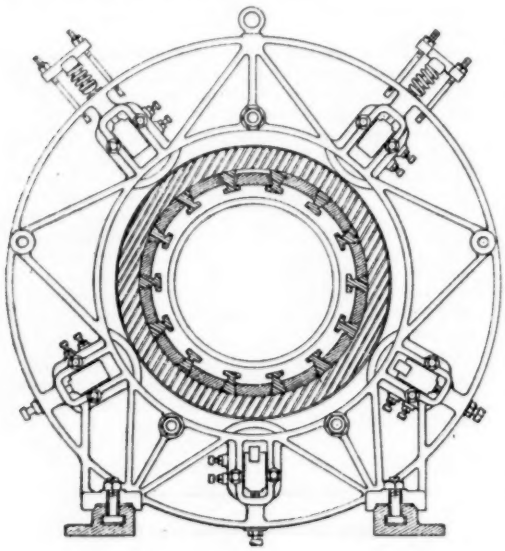
According to the "Iron Age," analyses for oxygen, hydrogen and nitrogen have been completed on samples of hard white iron and malleable iron from two plants melting in electric furnaces and from those plants melting in air furnaces. In all cases it was found that the annealing of the hard iron increased the oxygen content of the metal and decreased the nitride nitrogen content. No distinction between air furnace and electric furnace iron was found on the basis of the oxygen content or on the basis of the changes in oxygen or nitrogen. There was apparently in some instances a tendency for electric furnace iron to contain more nitrogen than air furnace iron in both hard and annealed conditions, but this difference was not true throughout the series of samples analysed. The ranges of gas contents were as follows: Oxygen in hard iron, 0.0014 to 0.0043; oxygen in malleable iron, 0.0060 to 0.0190; nitrogen in hard iron, 0.0080 to 0.0104; nitrogen in malleable iron, 0.0011 to 0.0036 per cent.

SIR PETER RYLANDS, ex-President of the F.B.I., interviewed on the probable results of the Allied conference on the iron and steel trade, pointed out that the steel industry had all along regarded the negotiations with mixed feelings. No doubt a recovery in the consuming power of Germany would be to the general advantage, but the steel trade could not be unmindful of the fact that steel was the greatest of the German industries, and the development of German production was likely to be reflected in increased competition. No doubt this could only be possible with a permanent lower level of wages in Germany, which the workers of this country would probably not feel disposed to regard without concern. The Government apparently entertained similar fears since it had decided to restore the 26 per cent. tariff on imports from Germany. But that tariff had its limitations. It would not prevent German products being sent here by way of Holland or Switzerland. Neither could it have any effect on competition in foreign markets. The 26 per cent. duty on imports from Germany was merely a partial and imperfect protection of our home markets. Only a general tariff could be an absolute safeguard. It was hopeless and useless for steel workers in this country to attempt to drive up wages if they were to be subjected, in their own home markets, to the competition of German workmen with their 60-hour week and much lower wages.

XUM

The Manufacture of Sheet Bars by the Cammen Process.

For the last two decades metallurgical engineers have been trying to devise commercial processes for the casting of a large number of small ingots from a large melting unit. The benefits sought are to incorporate all the economies to be associated with large-scale melting and the elimination of the cost of the reduction of large masses of metal to comparatively light sections. Mr. Leon Cammen, who is a well-known American inventor of centrifugal casting processes, has applied on a small scale his process to the manufacture of sheet bars at the Electro-Metallurgical Company, Niagara Falls, New York. The experiments have been sufficiently successful to warrant the installation of a large modern plant.



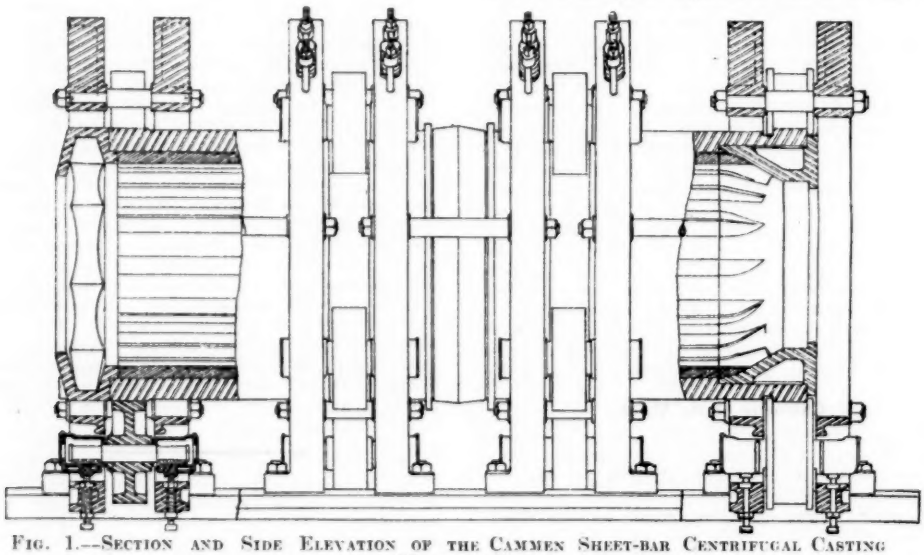


FIG. 1.—SECTION AND SIDE ELEVATION OF THE CAMMEN SHEET-BAR CENTRIFUGAL CASTING MACHINE.

For the commercial operation of such a plant Mr. Cammen envisages an open-hearth furnace of 90 to 100 tons, with a total output under American conditions of 1,000 tons in 24 hours. Where the total output is smaller, the cost per ton of sheet bars will increase. The actual casting would necessitate the installation of four machines of the type shown in Fig. 1. The four machines are capable of handling 2,500 tons in 24 hours, but the estimated cost outlined below is based on 1,000 tons. Each machine will cast at one time 14 bars, $8\frac{1}{4}$ in. × $2\frac{3}{4}$ × 12 ft. long, the total weight of metal cast by each machine at each operation being approximately 6 tons.

Casting Operations.

The metal is delivered to the machines in the ordinary 50-ton ladles, and is poured at the rate of about 2 tons per minute. A couple of minutes after the end of the pouring the bars are withdrawn from the machine, this being done by a combined hydraulic-compressed-air gear, and sent on their way to the re-heating furnace (which they reach still red-hot, and from which they go to the rolls), and the machine is ready for the next pouring. Each machine is taken care of by one man, with one foreman for a plant of four machines on the floor. The machines are equipped with patented gauging heads, which permit control to within about 0.02 in. of the thickness of the cast bars. The change of heads requires about three minutes.

The operation consists in casting solid bars centrifugally. The structure is obviously free from ingotism, and the defects ascribable to this phenomenon. Further, one can expect diminution of non-metallic inclusions.

The bottle-neck mould, which is incorporated in the designed and patented, renders possible the casting of bars or ingots without the formation of "cold shuts," which are otherwise difficult of elimination in divided moulds.

The total cost per ton of finished cast bars, delivered to the reheating furnaces ready for rolling into sheet bars of desired thickness from the cast thickness of $2\frac{3}{4}$ in., is estimated by Mr. Cammen to be 2s. 6d. per ton, which includes departmental labour, power, moulds, interest on capital outlay and depreciation.

A Blast Furnace for Experimenting in the United States.—A new blast furnace for experimenting, which embodies all the best features determined by observation of the performance of other furnaces constructed by U.S. specialists, has been completed and blown in at the Minneapolis experiment station of the U.S. Bureau of Mines. The furnace, which was erected in co-operation with the University of Minnesota, is 36 in. in diameter at the hearth and 30 ft. high. The first run lasted ten days. Air was supplied at the rate of about 600 cub. ft. per min., consuming about 8 tons of coke per day. From 15 to 20 tons of spiegeliron of varying manganese content were produced during the experiments. Several hundred gas samples were taken from the inside of the furnace shaft by water-cooled sample tubes. The most striking feature of the experiment in contrast with previous ones lies in the fact that a rather complete survey of the composition of the gas stream in the furnace shaft was possible. By introducing water-cooled sample tubes through various test-holes, it was possible to cover six planes. During two runs with the Bureau's furnace over 1,000 gas samples were taken at five elevations in the shaft. These samples, however, all lay along a single diameter of the furnace section. The necessity of sampling over a complete section has long been recognised, but the difficulty of obtaining such samples in practice has heretofore not been overcome.

Fuel Economy and the Measurement of High Temperatures.*

By Sir Robert Hadfield, Bt., D.Sc., F.R.S.

The author dealt with these subjects in three sections. The first formed an introduction recalling the importance of fuel economy during the late war and the post-war period, the latter especially in connection with the reduction of manufacturing costs. Reference was made to the importance of a knowledge of the temperature distribution in fuel-consuming plant, and to the comparative deficiency of knowledge of the effects of high temperature and the importance of research in this direction. Modern methods of pyrometry and some of the difficulties in their application also received attention. The second part of the Paper was devoted to a survey of the fields where pyrometry had enabled accurate heat balances to be obtained, including steam boilers, forge furnaces, and furnaces for the heat-treatment of steel, and open-hearth furnaces. The remainder of the Paper was devoted to temperature colours.

Steam Boilers.

The author pointed out with regard to pyrometric measurements on steam boilers that any scientific instrument was valueless unless the necessary care in use and periodic check of accuracy were assured. This applied in particular to the thermo-couple type of instrument. There were other types of instruments which might be used, notably mercury thermometers, protected in an iron sheath, but for routine work on large installations there was no type to equal the thermo-couple type. The recording or indicating instrument might be placed at the most convenient point, and it was only a question of wiring up to enable observations to be taken at any number of selected points.

In measuring the temperature of hot gases surrounded by colder surfaces with a pyrometer, continued the author, the temperature indicated by the instrument is always too low, for although heat is imparted to the exposed element by the hot gases being taken up by convection and conduction of the sensible heat in them, heat is also lost from the measuring instrument to the colder walls of the furnace by radiation. There is also the possibility of heat loss by conduction along the pyrometer rod. The rates of conduction and radiation and the error are diminished as the element is made smaller; but, strictly speaking, for absolute accuracy, observation would have to be extrapolated to an instrument of insignificant size. The chief cause of such discrepancies arises from the necessary protecting tubes which must be used to protect the vital parts of the pyrometer. Actual errors vary with conditions. The United States Bureau of Mines investigation found 20 deg. Fah. to be the average error in boiler flues. On the other hand, the error due to stratification of the gases may be of the order of 1 per cent. of CO_2.

The utilisation of high calorific intensities in boiler operation depends upon improvements in the material of which the furnace chamber is constructed, *i.e.*, both refractories and metallic materials. It calls for the provision of a double wall to the furnace chamber, refractoriness being the primary consideration for the inner lining, heat insulation that of the outer; it has not yet been found possible to obtain in one and the same material the maximum development of these two properties. There is a limit to the practical intensities of evaporation by reason of the failure of the tubes in the case of water-tube boilers. The application of the air heater to boiler plants is a growing development, though at present it appears that the range of actual improvement in efficiency is in the region of 5 per cent. But further application of this type of accessory to increase the output of steam will be more readily possible when the use of special non-scaling materials becomes general practice on mechanical stokers.

As regards the provision of steel capable of withstanding high temperatures, this is now an accomplished fact. This material is not only practically non-scaling at temperatures up to or even exceeding 1,050 deg. C., but is also resistant to the action of the sulphurous products of combustion, in this respect comparing favourably with the more expensive materials of the non-ferrous type known as nickel-chromium alloys. The steel also possesses remarkably high strength and tenacity at even up to about 900 deg. C., at which, as is well known, the strength of ordinary steel is practically negligible. This is another factor of considerable importance, because steel intended for use at high working temperatures must remain rigid.

Forge Furnaces and Furnaces for the Heat Treatment of Steel.

In furnaces of this type the measurement of temperature is an all-important factor. The metallurgical requirements demand almost rigid conditions of temperature distribution. This is also happily in the interests of fuel economy, going a long way towards reducing controllable operation losses. Advances in this branch of fuel economy have in the past largely been on empirical lines—necessarily so by reason of the complicated character of the subject. In the design of the plant itself, progress has had to follow almost on lines of guesswork, each step having to be proved under the confusing conditions of practice, which often vary considerably from place to place.

For common purposes of comparison it is the rule to judge of the operation of a furnace in the rather approximate terms of tonnage output and fuel consumed. Again, the relation of the furnace to the shop conditions is often a prime factor in deciding its operation; its efficiency then has to be judged in the general sense. The best "general efficiency" may not be consistent with the best "thermal efficiency." The aim of furnace design and operation should be to reconcile the two. Thus in heat treatment it is often realised that a particular operation is thermally inefficient. In fact, there are probably millions of tons of coal used annually for operations in which the thermal efficiency of the process, expressed as heat utilised in the material heated to the total heat output, is less than 15 per cent. The inversion of this figure to represent the heat wasted rather than the heat used is perhaps far distant, but not impossible in certain cases.

Temperature Measurement in the Furnace.

In determining the temperature of gaseous streams the radiation from hot material in the furnace introduces an element of uncertainty; but as regards the hot materials themselves, the optical pyrometer is a safe guide; where its use is not expedient, since it implies a more skilled control, recourse must be had to the naked eye. The lag in the thermo-couple type of instrument and the correct placing of the instrument in the furnace are points of importance. The flow of hot gases must be taken into consideration, and the effect of radiation from hot surfaces. As regards temperatures in the interior of the material heated, this is a subject about which more quantitative data of a general type are required. It is perhaps surprising that, considering the importance of the subject, more efforts to correlate the useful methods of a Fourier analysis with experimental data have not been made. Contributory reasons have been probably the facts, that it is relatively a simple matter to ensure uniformity in temperature by soaking, and that such treatment is often demanded by purely metallurgical considerations. Further, the soaking times necessary may be judged in quite a ready manner from the rate of heating and observations of behaviour in forging or rolling in cases where the material is worked down.

* Abstract of a Paper read before the First World Power Conference at the British Empire Exhibition.

Flame Temperature and Furnace Efficiency.

The bearing of flame temperature and temperature drop of the hot gases on the rate of heat transmission is of importance in furnace operation, for to arrive at the dimensions of the working chamber for any given load, the heat-transmission factor must be known. This has generally been arrived at for any given class of furnace in an empirical manner, from experience in the performance of previous furnaces. To obtain a quantitative expression of the fundamental laws governing the flow of heat from the hot gaseous stream to the medium heated is a complicated problem.

The temperature gradient in the furnace is the chief criterion of its operation. It may be governed by limiting conditions demanded by the process. For example, in the heating of ferrous metals excessive intensities are at times harmful. Thus in heating high-carbon steels a "soft" flame and reducing conditions are essential, which again in the present state of knowledge is purely a question for the eye of the operator. The manner of mixing the combustible gas and air governs these conditions to a large extent. Delayed mixing, by which the natural effects of convection flow are made use of by suitable spacing of the ports, is an advantage in this type of flame; or means may be taken to bring about an induction of the cooler burnt gases in the furnace into the hot stream. A certain amount of viscous drag and convection edding is inseparable from a slow-moving bulky flame, and gives the desired "roll" to it. In general it may be said that flame intensity in furnaces depends primarily upon physical questions of fluid flow. The total input of heat and the maximum realisable flame intensity must, of course, be determined by the chemical factor of the composition of the gas.

The natural speed of flame propagation, to which much attention has been devoted of late in connection with mine explosions, must, of course, also be a governing factor, particularly in flames rich in hydrocarbons in which the secondary water-gas reaction results in the formation of relatively high proportions of slow-burning carbon monoxide. However, the main desideratum of the reducing flame referred to is the free carbon, particles of which burn slowly because of the relatively large volumes of air that they must come in contact with for combustion, and the reduced mass action effect of the oxygen in the tail of the flame.

Regenerators and Recuperators.

The question of the design and dimensions of these appliances has been the subject of much inquiry. More recently mathematical solutions have been attempted, though it is realised that such methods can only serve to indicate lines of progress in so intricate a subject. Again, thermal considerations are limited by other properties of the refractories to be used, such as refractoriness, mechanical strength and resistance to spalling, chemical corrosion and abrasion. It has also been realised that there are limiting dimensions and arrangements of chequer work beyond which it is not economically advantageous to go. Thus analytical study of the thermal properties of various classes of brick have shown that the "brick efficiency" depends upon the dimensions and times of reversal. For example, 95 per cent. saturation of a silica brick is attained in 15-min. reversals, and 20 min. for firebrick under normal conditions. These figures apply to 2½-in. bricks, whereas for 3-in. bricks the times become 20 and 30 min. respectively. Provided it is practicable to measure the gas temperatures within required limits of accuracy, the proportion of heat recovered is given by the ratio of the temperature drop through the regenerator to the initial temperature of the ingoing heating gases, and the heat returned to the furnace by the rise in temperature of the heated air and a knowledge of the flow of gas and air. However, again the best thermal efficiency of the regenerative system may not be consistent with the best general efficiency of the furnace and its accessories as a whole. For example, a higher temperature of regeneration may only be attained at the expense of a higher outlet temperature of the waste gases.

Referring in particular to the recuperator, this is an appliance which should be capable of general application in furnace practice, but at present it is not, because of the limitations in the thermal properties of the materials which may be used. Amongst the disadvantages which militate against their more extended use are the relatively large bulk of material necessary for a given heat recovery and trouble arising from leakages and short-circuiting of the gases. The metal recuperator has its limitations for high-temperature work, but with the development of non-scaling materials having suitable thermal characteristics at economic prices they should come into more general use.

Heat Transmission and Heat Balance in Furnaces.

In flame furnaces the most uncertain factor is that dependent upon the combustion conditions. Thus a luminous flame is reputed to give a much better heat transmission owing to the radiant energy of the incandescent particles—a controversial question, and a view at variance with the results of the best scientific work on the subject. Again, little is known of the important question of flame volume in its relation to the rate of heat development, or of the factors which govern the heat transmission from flame by radiation or convection; particularly respecting the latter, whether the usual direct law of the temperature difference between the heating and heated media holds. As regards the heating effect of hot gases, convection is the dominant means of heat transmission below 800 deg. C.; above this limit radiation rapidly exceeds the effects of convection.

Whilst in practical operation the question of the generation of heat is inseparable from that of its transmission to the charge, in seeking for the directions of improvement it is necessary to consider them separately as far as practicable. In some cases, as in a producer gas-fired furnace, this is readily done, for the question of producer efficiency is as readily studied as any problem in fuel technology. There is one factor, however, which is difficult to assess, namely, the tars. This is not indicated by any ready means such as a gas analysis, or the usual temperature control. Again, an accurate knowledge of the amount of undecomposed steam, if not of serious consequence in the heat balance is desirable from other aspects. Its direct measurement in a ready and satisfactory manner is still one of the fields for profitable research. It may be deduced from a knowledge of the composition of the fuel, the temperature of the blast, and the composition of the gas; but it is doubtful whether this is satisfactory, as moisture taken up from the water seal introduces an uncertain factor. For control purposes in gas-producer operation the best guides in the author's experience are the temperature of the gas and the relation of the calorific value of the gas, as deduced from its composition, to the total contained carbon.

As regards the utilisation of heat in the furnace, a knowledge of the heat contents of the products of combustion and of the charge, and the means of estimating the efficiency of regenerative appliances, is of first importance. There is, however, the remaining loss in the furnace structure by conduction, and external losses, which are too frequently overlooked. This is bound up with the question of the lagging of the furnace. The heat distribution in the furnace structure itself is a fruitful field of inquiry. For their own purposes the author's laboratories have found it useful to devise a rapid method of measuring the heat diffusivity and conductivity of refractory materials.

Melting Furnaces.

In the higher-temperature processes of melting furnaces, temperature measurement is as important in its influence on both metallurgical and thermal considerations as in the lower-temperature operations of the forge or heat-treatment furnace.

The optical pyrometer, the technical application of which has made much progress in this field, is the chief scientific instrument. In actual practice, personal observation of the appearance of the metal, pouring and rod tests, largely hold the field as a means of heat control. In so far as the temperature of a molten bath is concerned, the last class of indications, *i.e.*, the action of the bath on rods inserted and manipulated in a variety of ways, is generally favoured as the most

reliable, and when the factors eventually come to be studied and the indications correlated to the thermometric scale, perhaps a scientific basis may be found for their use. At present the optical pyrometer must be the means for correlating that scale with these methods. Its value as an index of true temperature conditions depends upon the change of emissivity of the surface of the hot body. The question also as to whether "black-body" conditions are being observed, for example, as to whether the door opening is modifying them, has to be considered. With regard to fluid slags and special steels, the emissivity constants require revision.

With regard to the operation of the open-hearth furnace as a thermal machine, comparatively few accurate heat balances have been published. The fuel consumption of the open-hearth furnace depends not only on its efficiency as a thermal machine, but also upon metallurgical considerations, which may have considerable effect. The best index of the heating efficiency of the melting furnace is naturally the rate of melting, expressed in tons per hour. Many comparisons are met with, in which the fuel efficiency of the furnace is given as an overall fuel consumption per ton of output. In such cases it is not always realised that the major circumstances determining good fuel ratios have been purely metallurgical, namely, such factors as the percentage of scrap in the charge, its composition, the size of the material charged, the manner of charging, and then the length and character of the refining period, and fettling time.

From observations on the melting efficiency of open-hearth furnaces it may be said that such efficiency, based on the heat input to the furnace, varies from 20 to over 30 per cent., according to the size and character of the furnace and the composition and character of the charge. The utilisation of the heat losses in the waste gases is a difficult problem in those cases where steam from waste-heat boilers would be a useless by-product. These losses exceed 30 per cent. of the heating value of the fuel, and there is a practical limit to their use in the regenerative system, though a certain proportion must be regarded as useful in a sense, as it creates the chimney draft. The major portion of the radiation and conduction losses is from the working chamber itself, and their reduction is a question of improved refractory materials and higher rates of heat transmission in the laboratory of the furnace. Careful control and improvement of producer conditions not only influence the producer losses within a range of 10 per cent. of the heat of the fuel, but also contribute a comparatively greater share towards the general efficiency of the plant. The more recent developments in open-hearth design have tended towards what amounts to harder driving, brought about by improved flame conditions, as instanced by the McKune port, which attempts to get a blow pipe action on the surface of the bath.

French Steel Industry's Foreign Propaganda.—According to the report presented at the recent general meeting of the Compagnie Industrielle et Commerciale d'Exportation (Longovica), dealing with the new Company's second year of activity, the agency established in Argentina immediately after the constitution of the Company had a considerable turnover in iron and steel products and structural work in 1923. A sub-agency was established in Montevideo, and business relations were entered into with the provinces of Rosario and Santa-Fé. The Company has also an agency in Rio de Janeiro and a sub-agency in Sao Paulo, the latter of which was only opened in June, 1923, and has already been able to effect large sales of rails. The Calcutta agency is said to show very promising prospects, while the agency of the firm of Rateau in Spain has been taken over by the Longovica. At the end of last financial year an agency was started in Shanghai. The English agency has suffered from the events on the Ruhr, but has become very useful to the Company in ascertaining the possibilities of the English market and of the whole British Empire. The Bureau in Antwerp has continued to be occupied with transit business and shipments of the products intended for the over-sea agencies, while in Longwy itself business has been concluded with various European countries on the Mediterranean, the Baltic, and with Scandinavia.

Pulverised Fuel and the Ash Question.

FROM A CORRESPONDENT.

Controversy continues in this country concerning the amount of ash discharged from the chimneys in pulverised-fuel firing, and the subject is particularly interesting to the colliery and iron and steel industries in view of the possibilities of utilising high-ash content refuse fuels on this principle at a high efficiency. As is well known, two power stations in London are being equipped for pulverised fuel, and since about 3,000,000 tons of coal per annum are now being burnt by this method for steam generation in the United States and Canada, mostly in or near large towns, and the principle is extending rapidly, there obviously must be some mistake somewhere as regards the large quantities of ash which according to some critics are discharged from the chimneys of pulverised-fuel installations.

A short time ago Mr. John Anderson, of Milwaukee, who was in this country recently, gave to a gathering of well-known engineers a detailed account of the Lakeside station, and a mass of data regarding the costs of operation, the auxiliary power, wear and tear and maintenance, labour charges, and many other items of the Lopulco system of pulverised fuel in operation with the original 40,000-kw. plant, started up in December, 1920, and the new 60,000-kw. set now in operation. A further 30,000-kw. unit is under construction and a maximum station capacity of 200,000 kw. will eventually be obtained. Over 1,250,000 tons of coal have already been burnt at Lakeside, and Mr. Anderson said there had been no trouble at all with ash, either at this station or any other modern equipment in the whole of America.

In the first place, the amount of ash actually discharged has only been determined accurately at two places in the world—Lakeside and Oneida Street, both in Milwaukee. The figure depends on the rating of the boiler, but roughly it seems to vary from 15 to 30 per cent.; that is to say, from 2¼ to 4½ per cent. of the weight of the coal fired. With modern mechanical stoking the ash discharged is probably about 3 per cent., practically the same, a fact not generally realised; but it has to be remembered that pulverised-fuel ash is, to begin with, pure mineral matter only, without any unburnt material, and, secondly, it is in such an extraordinarily fine state of division that it would normally remain suspended in the air for a long period, like particles of salt from the sea. The coal itself is of course already ground to the equivalent of about 65 per cent. through a 200-mesh, and the particles of ash, much smaller in size, seem to be spread over a vast area, many square miles, being washed down with every shower of rain. Mr. Anderson says it would not matter if 90 per cent. of the ash were discharged, and Mr. H. D. Savage, of the United States, in his detailed Paper on the subject, shows that even on this assumption the amount of ash deposited round the station would be less than an ounce per square yard per annum. It appears also that 60 per cent. of the ash passing up the chimney can, if necessary, be removed by a simple form of washer, and the Trenton Channel Station of the Detroit Edison Company are fitting electrostatic dust separators with an efficiency of 99 per cent.

The time will probably come when all smoke and dust from chimneys will be prevented; but on our present knowledge this would seem to be a much more difficult matter with existing hand- and mechanical-firing. The utilisation of high-ash refuse fuels therefore presents no difficulties as regards high efficiency and the dust from the chimney, the real factor of importance being the increased cost of grinding per unit of heat content.

Two large vessels arrived at the Senhouse Dock at Maryport last week with ore from Poti and Sapolette, and the imports for the week amounted to about 8,000 tons.

Second International Danzig Fair.—The second International Danzig Fair is to be held from October 2 to October 5. As known at present, fourteen countries will be represented at the Fair, and the demand for stands has been so great that additional halls have to be erected.

Making a Lead Melting Pot in Loam.

BY A. GREENHALGH.

The object in making this in loam was to curtail the expense of pattern-making, the job not being one which would make it worth the cost of making a pattern, just for the sake of one casting. Fig. 1 shows the general appearance of the casting. It will be seen that two boards were required, one to strickle the top and one the bottom. The outlet pipe at the bottom was made with a core and built up in the brickwork. A top-plate, a bottom plate and a binding ring were required. The bottom plate was placed upon stands, the spindle seating

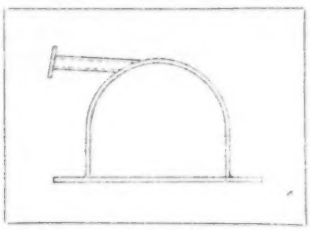
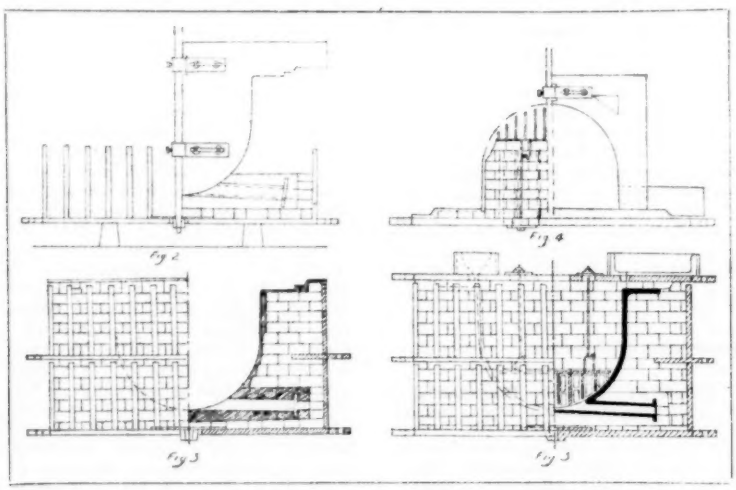


FIG. 1.

being clamped to the bottom plate, which did away with the trouble of getting the plate square to the spindle as would be required if not fastened together. The spindle having been placed in position, the board for bottom was fixed to the arms on the spindle. A layer of bricks was laid on the bottom, the crevices being filled up with small ashes to carry off the gases. The core to form the outlet pipe was then placed in position, being bedded on loam as shown in Fig. 2. The core having been set, building up was carried on, the binding ring being used when the mould had been built up about half way. After being "roughed up," it was allowed to stiffen and then "slipped up." The bottom was then ready for stoveing. Fig. 3 shows the mould at this stage. The top plate was placed upon the same stands, with the spindle seating



fastened to the underside of the plate. The top plate had to have prongs cast to it, to give support to the dome-like structure of the top part. The strickle board having been fixed, building up was carried on. The middle of dome was left hollow. The crevices between the bricks being filled with ashes and trailed to the centre. The dome having been built up about half way, a smaller plate with prongs was placed on top and bolted to the top as shown in Fig. 4. The rest of the dome was now bricked up, plenty of loam brick being used—the same process of "roughing up" and "slipping up" taking place as in bottom part. After having been thoroughly dried the mould was "dressed," that is, any cracks that had appeared during drying were made up with soft loam. The mould was rubbed over with sandpaper to take off the roughness; they were then "blacked" and the mould was ready for closing. The bottom part was now set in position for casting, preferably sunk to some extent in the floor for convenience in casting.

The pipe-core was placed in position. This rested between two chaplets at one end the other being in the print. Allowance was made for pushing the core a little way through the print, so there was no danger of crushing the core when the top was tried on.

The top was then put on, and the pipe core pushed up until it touched the top. Runner and risers were made, the job being run on the top; after weighting the job was ready for casting. Fig. 5 showing completed mould.

Foundry Queries.

Nickel Castings.

We are making a series of light castings in nickel, and are experiencing great trouble from blow holes on the surface. We shall be greatly obliged if any of your readers can give us any advice respecting the cause, and the cure.—T. W. A.

Cupola Receivers.

Can any of your readers tell us of the advantages and disadvantages of using an open receiver instead of tapping straight out of the furnace pit into hand shanks?

It seems that the metal would be cleaner if a receiver were used, but there is a danger of its getting too cold.

In any case, we shall be very interested and grateful for any information you have upon the subject.—"N." FOUNDRY COMPANY.

[Mr. F. J. Cook, in a discussion upon this question arranged by the Birmingham Branch of the Institute of British Foundrymen, reported in our issue of December 7, 1922, summarised the question as follows:—"The advantages were that the metal was removed from the coke as melted. It was not contaminated by lying in the coke, particularly if the coke was sulphury. Instead of the metal lying between the spaces of the coke it all came out into the receiver, and the metal was poured over two spouts, which gave better mixing than just dropping it in between the spaces and drawing out with one tap, it being clear of coke and allowed the metal to free itself from slag better. It also permitted a better chance of freeing itself from manganese sulphide, being kept very hot by the flames playing on top of it. There was, of course, the saving of bed coke, which was quite an appreciable factor. Against those advantages they had the disadvantage of cold metal, due to the warming up of the receiver, and in that respect he thought a receiver inside the cupola was the most advantageous; in addition to which there was the extra labour in connection with the fettling and looking after the receiver."—EDITOR.]

Manufacture of Synthetic Foundry Iron in the Electric Furnace.*

By C. E. Sims, C. E. Williams and B. M. Larsen.

The manufacture of synthetic cast iron is an industry that was created and nourished by war-time conditions, and when the stress of war needs ended interest in it practically died, and is now only slowly reviving. However, with increasing knowledge of proper methods of production and a growing demand for high quality castings, it is expected that this revival will continue and put the industry on a successful peace-time basis.

The manufacture of synthetic foundry iron would create an outlet for a large quantity of scrap iron and steel of such a nature that it is now difficult to dispose of or which is being put to uneconomical uses. It should be a boon to the founder who is at a distance from an iron-producing centre, and must pay an excessive price for pig-iron and often experiences difficulty in obtaining the quantity or quality of iron that he needs.

Conditions in the far western States of America, where pig-iron and good foundry coke are expensive and iron and steel scrap and electric power comparatively cheap, are particularly well adapted to this industry. These conditions make cupola melting less desirable and favour the production of synthetic foundry iron, which is essentially an electric furnace operation. The same furnace equipment can be used either for the electric melting of foundry iron or for the production of synthetic cast iron, so that instead of requiring a specialised apparatus the production of synthetic foundry iron employs an instrument of general usefulness. Since the carbon content of the product can be varied between wide limits and silicon and other alloys can be added easily, grey or white cast iron, or other similar products may be made with equal facility. One particular field in which synthetic cast iron has an advantage is in the production of low phosphorus castings. For certain kinds of castings, such as ingot moulds which must withstand abrupt temperature changes, low phosphorus cast iron is necessary, and low phosphorus pig-iron is not always available. Phosphorus cannot be removed from pig-iron, but synthetic cast iron made from steel scrap would, of course, be low in phosphorus. Furthermore, as there is a rapid growth in the trend toward definite specifications of iron to be used for special purposes, the fact that synthetic foundry iron of any desired composition can be made makes it particularly valuable.

Although a carbon content of 3 per cent. is sufficient for many grades of castings, the great majority will require 3.25 to 3.75 per cent., and very few contain less than 3 per cent. If the synthetic cast iron is to be pigged for future cupola use, it should contain from 3.75 to 4 per cent. carbon.

Carburisation Difficulties.

Although the most important factor in producing synthetic cast iron is obviously that of introducing the requisite amount of carbon, this is the very point where most of the work done has been weak. Turnbull in his early work was rarely able to get carbon over 3 per cent., but in his later improved operations occasionally reached 3.5 per cent. He stated that it was extremely difficult to raise the carbon above 3 per cent. in a roofed furnace without great damage to the roof and that all high carbons were obtained in open-top furnaces. Likewise, Keller mentions 3 per cent. carbon, and gives one analysis of a white iron containing 3.55 per cent. carbon. In discussing Keller's article, Brooke said it was easy to obtain a carbon content of 2.75 per cent., but was difficult to get one of 3.75 per cent., especially if a roof was used. Richards, in the same discussion, reports that the use of the roof was abandoned in order to obtain the high carbon content of 3 per cent. Cawthon found that over 2.75 per cent. carbon could be introduced by cleaning the bath free from slag and agitating with a green pole.

The factors affecting the rate of carburisation were studied by the authors and reported in a Paper presented before the Baltimore meeting of the American Electrochemical Society in April, 1922. This Paper outlined the best conditions for rapid carburisation, and showed that from 3.5 to 4 per cent. carbon can be introduced without difficulty. By holding the molten metal in the furnace in contact with the carburiser, a product containing as much as 4.8 per cent. was obtained. The experiments described in the Paper referred to were conducted in a 50-lb. open-top pit furnace and in a 300-lb. roofed direct-arc tilting furnace. The roof furnace was found to be preferable, and even when producing a carbon content of 4.8 per cent. no unusual damage was done to the roof, although it must be remembered that the furnace was small and the pressure on the refractory in the roof not as great as it would be in a large furnace.

Factors Governing Carburisation.

It was found in these tests that the following factors contributed toward rapid and complete carburisation:—

(1) Use of a carburiser of as low ash content and as high density as possible; (2) absence of siliceous slag; (3) the addition of lime to flux the ash introduced when high-ash coke is used; (4) high temperature and direct arc; and (5) early removal of sulphur by use of a lime slag.

In order to determine whether the results obtained in those small-scale tests would apply with equal weight to commercial operation, several charges were run in a basic-lined Héroult-type furnace used for melting steel at the Lamb Machine Company in Hoquiam, Washington. The furnace was rated at 3,000 lbs., and took an input of about 400 kilowatt. Inasmuch as this appeared to be under-powered for carburisation work, only 2,000 lb. charges were made. The steel scrap used was a mixture of blacksmith shop scrap, corroded boiler flues, cast-steel sprues and gates, boiler punchings, etc. Runs were made using high-ash coke containing about 30 per cent. ash and retort coke practically free from ash in order to determine the effect of ash content of the carburiser. Ferro-silicon and ferro-manganese were added in the quantities required.

The progress of carbon solution was watched by inspecting fractures of slowly-cooled samples taken at intervals from the furnace. This method has proved very satisfactory when used by an experienced operator. After the desired amount of carbon, between 3.5 and 3.8 per cent., had been introduced the metal was poured into ladles and thence into moulds for a variety of castings, such as pulley wheels, bushings, grate bars, etc., satisfactory castings being obtained in every instance.

The results proved that the conclusions arrived at as a result of the small-scale tests in the laboratory applied equally to large-scale operations. The presence of a siliceous slag deterred the rate of carburisation, a large amount of slag practically preventing any introduction of carbon; carburisation took place rapidly if the surface of the metal was kept clean; high-ash coke was less effective than coke of lower ash content; and finally the carbon content of the product was adjusted to the desired point by holding the metal in the furnace and observing the nature of the fracture of ladled samples.

Keller used fine turnings with coke in approximately the same state of division, and contended that with such an intimate mixture carburisation started far below the melting point, and was largely completed before the charge had melted. Our experiments have shown that this is not true, but that very little carbon is introduced until the scrap is molten. The heaviest steel scrap that could be put into the furnace carburised as rapidly as fine turnings and borings. Molten iron was

*A Paper presented to the American Foundrymen's Association. The authors are attached to the metallurgical staff of the North-west Experiment Station, United States Bureau of Mines, at Seattle, Wash.

found to absorb carbon up to 2.5 per cent. with great rapidity when allowed free contact. Strips of Armco iron, whose melting point is near 1,500 deg. C., were placed in a tall crucible with ground retort carbon at the bottom and heated *in vacuo*. No action was noticed until a temperature of about 1,250 deg. C. was reached, when melting started and was completed in a fraction of a minute. It seemed that the small portion of the iron in actual contact with the heated carbon, after reaching the plastic state, became sufficiently carburised for the surface to melt. This molten portion rapidly carburised to 2.5 per cent. carbon, and acted as a flux to melt more iron, which, in turn, was carburised. Thus a progressive fluxing, melting and carburision is set up, which quickly changes the low carbon solid iron to high carbon molten iron much as salt melts ice below the freezing point of water.

Attempts have been made by numerous investigators to produce synthetic cast iron in the cupola. Robert E. Masters reports that he melted steel in the cupola over 50 years ago, and Moldenke has melted thick steel scrap, using large fuel ratios. Moldenke also described a German process for making synthetic foundry iron in which steel borings are briquetted and melted in a cupola with ferro-silicon and a large excess of coke. Valuable information regarding the extent of carburisation obtainable in the cupola was obtained by the research department of the Rombacher Hütte in Coblence. The cupola was first charged with coke to 7¾ in. above the tuyeres, then more coke with limestone was added, followed by additions of low-carbon steel scrap, limestone and ferro-silicon. The carbon content of the products obtained, using light scrap, was from 2.70 to 2.95 per cent., and that of products from heavy scrap was from 2.75 to 3.35 per cent. Much slag was formed, which attacked the lining badly. Later, molten steel was poured through a column of hot coke in a cupola. The metal obtained by this treatment contained usually from 2.6 to 2.8 per cent. carbon. When charcoal was used instead of coke, in most cases the metal produced contained more carbon than this, although the analyses reported varied from 1.90 to 3.56 per cent.

Experiments conducted by the authors using a small cupola proved that steel scrap is only melted with difficulty with high-ash coke (20 per cent.), and that using retort carbon the operations are smooth, but that the carbon content of the metal is not high, usually about 2.5 per cent.

As a result of the above observations, it seems that the production of synthetic foundry iron in the cupola is impracticable, because of (1) the inability to obtain, consistently, a metal of high-carbon content; (2) the excessive slagging and its consequent troubles; (3) the large proportion of coke required and the consequent introduction of a relatively large amount of sulphur; and (4) the large loss of silicon by oxidation.

From the above discussion, it is seen that both electric furnace and cupola melting tests have shown that 2.5 per cent. carbon is readily introduced into iron by melting steel scrap in contact with carbon, that this amount of carbon is absorbed shortly after the steel is melted, and that a relatively longer time is required for the introduction of more carbon. In the electric furnace carbon contents of from 3.5 to 4.0 per cent. can be easily obtained by adhering to certain requirements which will be outlined in the following discussion.

Best Operating Conditions.—Raw Materials.

Practically any ferrous scrap can be used, low- or high-carbon steel, wrought iron, malleable, white, or grey cast iron scrap being equally desired. Scrap from manganese steel, or high silicon irons, which is often not in demand by the ordinary market, is wanted for synthetic iron to bring up the manganese or silicon content of the iron. The sulphur and phosphorus content need not be limited, since the scrap containing these impurities can be mixed with other scrap to reduce their content, and the sulphur is largely removed if a lime slag is used. From the metallurgical standpoint the scrap may be in the form of fine turnings and borings, or heavy sections, the state of division having no effect upon the operations.

Carburiser.

The purest and densest forms of carbon are the best carburisers. As the ash content of the carbon increases, more of it must be used and the rate of carburisation will be slower. Artificial graphite electrode or resistor carbon, petroleum coke, gas-retort carbon, and pitch coke are the best carburising materials. Wood charcoal ranks high because of its purity, but is not as effective as the ones mentioned above, because its apparent specific gravity is so low that it floats on the bath, giving poor contact. Coke and anthracite coal of low-ash content come next in preference, and the high-ash cokes last. Carburisers of high-ash content should be used with a lime slag, and the latter removed once or twice during the carburisation period. Silicon carbide is an excellent carburiser, but must be used with one of the forms of carbon above mentioned, and only in sufficient quantity to introduce the required silicon in the metal.

Addition Agents.

Ferro-silicon or high silicon iron are best for introducing silicon, although silicon carbide in the form of "fire-sand" has proved both cheap and effective, and is also valuable as a carburiser. Silicon may be introduced by the reduction of a siliceous slag, but difficulty is experienced in regulating the reduction to give the required silicon content. Another objection to the introduction of silicon by this means is that a siliceous slag retards carburisation. Therefore, considering the extra power required to reduce the silicon and the excessive time needed for carburisation using a siliceous slag, the introduction of silicon by this means is considered undesirable.

Any alloy of iron and manganese is satisfactory for the introduction of manganese, the choice depending upon the cost.

If desulphurisation is required, either lime or limestone mixed with fluorspar should be used. The use of silica in the slag must be avoided to obtain rapid introduction of carbon.

Type of Furnace.

The furnace operations in the manufacture of synthetic foundry iron are similar to those in the ordinary melting and refining processes for iron and steel, hence the type of electric furnace used for the two processes would be essentially the same. For rapid carburisation, hot metal and good contact between the carbon and the iron are necessary. The direct arc furnaces used in steel melting satisfy these conditions in an excellent manner. In them, the heat is applied directly to the charge; the metal just under the electrode is superheated, and its avidity for carbon increased thereby, and the action of the arcs on the metal and the magnetic flux of the current cause a stirring and mixing action which affords exceptionally good contact between metal and carburiser. The indirect-arc furnace, if rocked or rotated, would give excellent mixing, but the stirring action of the arc and current would be less intense.

Continuous melting in the open-top pit furnace has been advocated. In this type of melting, however, it is impossible to raise the temperature above the melting point of the charge, while in the match-run superheating can be carried on to any desired temperature. Therefore, as there is practically no carburisation or desulphurisation before actual melting, and as both these actions take place much faster and more thoroughly at an elevated temperature, the advantages of the batch melting are evident. Especially where the metal is to be cast direct from the furnace is it necessary that the operation be flexible and the composition easily and accurately controlled. The use of a roof has been shown to be practical, and it is advantageous in facilitating the control of the furnace temperature and atmosphere. Although a tilting furnace is not necessary, it is a great help in the charging, pouring, and slagging operations.

The proper lining is one of the most important features. From the numerous tests made it appears conclusive that a basic or carbon lining is necessary. It is extremely hard to get a 3 per cent. carbon iron when using an acid-lined furnace or an acid slag. Many of the failures of other investigators to make iron of high carbon content

can be laid to a slag high in silica. A basic lining and a basic slag must be used if desulphurisation is done. The hearth may be made of dead-burned or sintered magnesite, a mixture of magnesite and alumina, dolomite, or carbon, rammed in with a bond. It should be broad and shallow to give as large a surface of metal as possible. The walls should be magnesia brick to a short distance above the slag line.

The furnace, therefore, need not be a specialised type, but of standard design that can be used interchangeably for iron or steel melting. It should, however, be constructed for easy charging of voluminous material and should have tight-fitting doors and electrode rings.

Method of Operation.

The methods of operation that have been found to give the best results are given below. Naturally continuous operation is most economical. About seven parts of carburiser are used per one hundred parts of steel scrap. In charging, half of the carburiser is placed in a layer on the hearth, so as to come under each electrode and form a continuous train. The steel scrap is then charged and the rest of the carburiser placed on top of this. If desulphurisation is to be accomplished, the lime-fluorspar mixture may be added at this point. The doors are then closed and melting is started. A dual voltage control is desirable using 100-120 volts during the melting stage and 70-80 volts for final carburising and refining. The electrodes will quickly melt their way through the charge to the carbon train at the bottom which will then carry the current. This is desirable; for the carburiser will quickly reach incandescent heat and will itself aid in melting and carburising the steel. The melting will thus be from bottom upward and the carbon will always be in contact with the molten metal. The arc will be buried in the unmelted part of the charge which will absorb the reflected heat and at the same time protect the roof. After the charge is all molten, enough carburiser should be kept on the surface to maintain a partially smothered arc. This will insure smooth operation and will be easier on the roof. Too deep a layer of carburiser should be avoided as it will cause the current to short-circuit and pass above the metal with consequent loss of efficiency. Any slag that accumulates should be skimmed off unless a desulphurising slag is being used. If a high-ash coke is used, better results will be had by maintaining a strongly basic slag to flux the siliceous ash from the coke and thereby speed up carburisation. If a low-ash coke is used and desulphurisation is not required, it is far better to use no slag at all and to keep the surface of the melt free from everything except the carburiser.

As soon as the metal is melted and at intervals of about fifteen minutes thereafter a small sample is ladled from the bath, poured into a mould, and allowed to cool slowly to a red heat. It is then quenched and broken for examination of the fracture. If the material charged was corroded or oxidised, the first sample is apt to be gassy, a condition that is quickly overcome by the intense reducing atmosphere of the furnace. When a sample shows thorough deoxidation, the ferro-silicon and ferro-manganese are added in the required amount. The advantages of adding the ferro-silicon at this point are two-fold; first, loss by oxidation will be avoided; and, second, after it is added, the spoon samples will show the normal fracture and the carbon can be closely estimated from the amount of graphitisation shown. The time required for carburisation will vary according to the amount of carbon desired, but will not be over half the time required for melting. During the final carburisation, the metal should be held at a temperature of a least 1,400 deg. C. and cast at 50 to 100 deg. less than this.

Costs.

In discussing the cost of manufacturing synthetic foundry iron many variable factors must be considered. Pig-iron may be produced as a primary product of a plant, or castings may be made directly and marketed as finished articles. If pig-iron is made, it must be produced at a cost lower than the market value of pig of similar quality in the same locality. Obviously, this phase of manufacture would have limited application. The production of castings, however, has more promising possibilities. This operation may be looked upon from two different standpoints; first, the foundry making a variety of castings could use steel scrap in place of more expensive pig-iron, the manufacturer of synthetic foundry iron being incidental to the main business of operating a foundry; second, an organisation established for the purpose of making synthetic pig-iron could make a product such as cast iron pipe that could be produced on a large scale and yet would sell at a higher unit cost than would pig-iron, the production of the synthetic foundry iron being the main operation and the casting department only incidental.

The saving that can be effected by direct casting over pigging, for subsequent melting, includes the following:—(1) cost of handling of the pig; (2) cost of melting in the cupola which has been variously estimated as between £1 and £2 per ton, and (3) the extra time, power, and materials required for producing pig-iron which must contain more C, Si and Mn than iron castings; the cost of these will amount to perhaps one or two dollars per ton.

The cost and nature of the scrap available will vary greatly. There will be competition for the good grades of heavy scrap by open-hearth steel plants and foundries, although some heavy scrap is of such nature as to make it unfit for use in the open-hearth furnace, and yet may be valuable for synthetic cast iron. Light scrap, turnings, and borings will be in demand for use in blast furnaces, if they are in close proximity to the source of supply. Inasmuch as the cost of scrap is dependent upon the demand for it, it would be expected that a new industry using a large tonnage of scrap would cause the cost to increase in proportion to the new demand.

There are hardly two localities in the United States where power rates are exactly alike, but the tendency in growing communities is for lower rates for large steady users of power. Exceptionally low rates for off-peak and seasonal power are now made by some companies.

No estimates of the cost of production will be given here because of the many variable factors involved and the impossibility of choosing one condition that will apply throughout the various parts of the country. However, the quantities of materials required and power consumed are listed in Table I, so that calculations may be made to suit any conditions that may be under consideration.

Actual Costs.

Materials required to produce one ton of synthetic cast iron containing C-3.50-3.75 per cent., Si-2.0 per cent., Mn-1.0 per cent.

TABLE I.
Materials and Power Consumed.

Steel scrap, turnings, borings, etc. ...	2,000 lbs.
Carburiser	140 lbs.
Ferro-silicon 50 per cent.....	80 lbs.
Ferro-manganese 80 per cent.....	10 lbs.
Electrodes (graphite	10 lbs.
or carbon)	24 lbs.
(Limestone	150 lbs.
or Lime)	75 lbs.
Fluorspar	20 lbs.
Power	750 kw.h.

At first glance it would seem that in this estimate no allowance has been made for melting losses. However, when one considers that about 3.5 per cent. of carbon, 4 per cent. of ferro-silicon, and 1 per cent. of ferro-manganese will be added to the metal, it will be seen that in reality a loss of 8.5 per cent has been allowed. The experiments have shown that, when starting with a hot furnace, a carbon content of 3.75 per cent. can be obtained with a power consumption of 650 kilowatt hours per ton, as indicated by the watt-hour meters. In the estimate, 750 kilowatt hours are used to represent the power consumption based on the maximum demand. Lime and fluorspar will be required only when the scrap contains much sulphur or is contaminated with siliceous material. The time of melting will vary with the power input to the furnace but will ordinarily be from 1 to 2 hrs., and the carburisation period from 30 to 45 mins.

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A German Research Station for Pulverised Fuel.

In order to study the conditions under which pulverised fuel is burned in metallurgical furnaces the Government smelting works of Saxony decided on establishing a research station, which now comprises four different pulverisers, two of which work on the "unit" system delivering pulverised fuel together with a certain amount of air directly into a pipe line and from there into the furnace; while the other two pulverisers deliver by screw conveyors into storage bins whence the fuel is fed into the furnace by a screw feeder and fan. A report just published in "Metall und Erz" is of more than common interest, the tests having been carried out on strictly scientific lines yet not losing sight of practical work. Many problems of interest to combustion engineers have been studied, and brought nearer to solution.

Using pulverised fuel in metallurgical furnaces appeared to be promising from the very outset, as high temperatures, which are essential with processes of this kind, are a particular feature of the pulverised fuel system. How important high temperatures are was demonstrated by the fact in the research station that in a certain case where the smelting process required 1,295 deg. C., the duration of process was increased by 20 per cent. compared with the time when working with a flame temperature of 1,445 deg. C.

The superiority of working the furnace from storage bins instead of using the "unit" system has been very clearly proved, because any change in the working of the furnace, due, for instance, to the changes of chimney draft, reacts on the pulveriser in the case of the "unit" system and causes fluctuations in the quantity and fineness of the pulverised fuel produced.

Much information has been gained as regards how to prevent the pulverised fuel from choking up the bins and how to keep the working rooms free from dust, also in regard to improved construction of flue gas valves, keeping them cool by sprays of water, etc.

The principal problems dealt with, however, concerned the size and shape of the combustion chamber and the correct way of introducing the fuel and air mixture into the furnace in order to convey the high temperatures required to the right spot and further to study means for preventing destruction of the firebrick linings of combustion chamber and furnace.

The author calculates the theoretical amount of what he calls the "maximum load of combustion chamber," which he finds to be practically of the same size irrespective of the kind of fuel used, viz., about 33,500 B.T.U. per cub. ft. Although in his calculation he arbitrarily assumes a certain length of time which the gasified and completely burnt fuel requires for passing through the combustion chamber, the figure arrived at by him seems to be confirmed by practical tests. The author insists on the combustion chamber being at any rate large enough to enable the chimney draft to conduct away freely the gas developed, and that no flames issue out of the ports of the furnace. This will go a long way to prevent the brick linings from being seriously attacked by the flames.

The furnace experimented with was a copper-refining furnace of the common reverberatory type, the hearth measuring about 6 by 13 ft. In such a furnace in which temperatures between 1,285 and 1,480 deg. C. are required on the hearth it has been found necessary to produce a long flame (similar to that in furnaces fired with gas), which was obtained by blowing the pulverised fuel into the combustion chamber with only a small amount of air (about 15 per cent. of the total amount required for complete combustion) and adding secondary air at a point situated beyond the first part of the hearth. In order to make the heat to radiate effectively out of the combustion chamber to the metal bath the combustion chamber was made elliptical, the major axis of the ellipse forming an angle of about 30 deg. with the level of the hearth. Further, to produce a flame which was fiercest along the centre line of the furnace and decreased in fierceness towards the outer walls, the fuel was injected through six nozzles spread across the whole width of the combustion chamber, the six nozzles being joined to a common pipe outside into which the fuel was fed from both ends. The two streams thus meeting in the centre of the pipe caused the nozzles at the centre to be fed stronger than the outer ones. In a similar way 12 nozzles above the hearth were fed with secondary air. All experts who inspected the plant at work praised the homogeneous flame spreading over the whole width and length of the hearth. It appears from this that the principles which have heretofore guided the construction of gas furnaces and which consisted in an efficient splitting up of the streams of gas and secondary air, the latter entering the furnace at a well-chosen point so that finally a good mixture and a long flame are obtained, will equally apply to burning pulverised fuel in furnaces.

The necessity of using a long flame, *i.e.*, of burning the fuel gradually as it travels along over the hearth is demonstrated by the author by a theoretical investigation. He shows that in the case of complete combustion being already attained within the combustion chamber the gases carrying a heat of 1,495 deg. C. into the furnace proper and cooling down there to 1,295 deg. C. would just deliver sufficient heat to compensate the radiation losses of the brick walls to atmosphere, no sufficient heat being left for heating the metal.

A drawback of retarded combustion or using a long flame is that the ash deposits on the hearth; this may be overcome to a certain extent by a strong chimney draft.

While experimenting with pulverised fuel in a metallurgical furnace much information may be gained about the metallurgical process itself. Heretofore, when using solid fuel or producer gas, neither the quality nor the volume of flame could be kept uniform for any length of time, as both these requirements were influenced by the charging of fuel taking place periodically and by the changing condition of the fuel bed. With pulverised fuel, however, the coal is charged into the furnace continuously, and may be controlled so accurately that the composition of flue gases and their temperature can be kept absolutely constant for any length of time. Changes in the composition and temperature of the flue gases indicate certain reactions going on within the metal bath, and such changes if duly recorded can be used as a basis for the regulation of the metallurgical process. Very good results are reported in this respect, which are confirmed by highly instructive charts and tables.

The author does not claim that every point has been cleared up relating to the subject dealt with, but rightly observes that the investigation by the research station will help progress, and that giving full publicity to the results attained may lead to a profitable exchange of opinions.

The salvage of German warships at Scapa Flow is proceeding satisfactorily, and Messrs. Cox and Danks have now got two destroyers beached on Millbay Sands, and a third is being fitted with its set of steel wire ropes for lifting operations. It is not intended this year to tackle either the *Hindenburg* or the *Seydlitz*, the two battle-cruisers included in the original contract.

The recent statements that have appeared in the Press, to the effect that Messrs. William Jessop & Sons, Limited, of Sheffield, had disposed of their American interests, are incorrect. Messrs. Jessop have sold their Washington Works, but they have not disposed of their interests in America, and have still the right to sell Sheffield steel through all their agents in America and Canada.

It is reported from Wellington (N.Z.) that a deputation of British manufacturers and agents have protested to the Prime Minister against a part of the contract for the material for the Arapuni hydro-electric scheme going to Swedish firms. Mr. Massey pointed out that New Zealand wished to give every possible opportunity to British manufacturers, and he would have been pleased if the whole contract could have been given to British works, but there was a difficulty in regard to part of the machinery in which Sweden specialised. The proportion to Swedish had been reduced to £64,000 of a total of more than £1,100,000. It was said to be impossible to obtain the necessary material elsewhere than in Sweden without calling for new tenders, which would involve serious delay.

The Metallurgy of Aluminium.

By F. A Livermore.

HISTORY.

The word "alumen" or its Greek equivalent was formerly applied as a grouping term for substances with astringent tastes. The number of processes devised up to the present time for the production of aluminium is very large, but only a few have attained in their application an industrial significance. It was shown by J. H. Pott in 1746 that alum was really an argillaceous earth. About 1760 Morvean introduced the word "Aluminium" for the substance obtained by calcining alum—alumina. It was supposed that Lavoisier first suggested the existence of the metal in the form of alumina contaminated or combined with the metallic bases and alkalies of the earth's crust.

Davy made many attempts to decompose the clay by means of an electric current, but all in vain. However, F. Wohler, in the year 1824, seems to have been the first to reduce aluminium by decomposing aluminium chloride by potassium.

$$AlCl_3 + 3K = 3KCl + Al.$$

Wohler's first experiment furnished a light grey metallic powder, but late in 1845, by passing aluminium chloride vapour over potassium contained in platinum boats, he obtained small globules of metallic aluminium. The metal at that time was a chemical curiosity, and for nearly 25 years its properties *en masse* were unknown.

Bunsen and Deville, in 1854, independently obtained the metal by the electrolysis of fused chloride. The result of the comprehensive investigation of the metal by Deville raised it from the rank of a curiosity into the list of useful metals; he is rightly termed the founder of the aluminium industry.

CHEMICAL METHODS OF PRODUCTION.

Henri Deville's Process.

In 1855 H. St. C. Deville prepared large amounts of aluminium by reducing the natural mineral

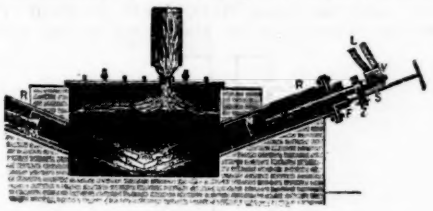

FIG. 1.—COWLES' FURNACE FOR REDUCING ALUMINIUM FROM ALUMINA.

bauxite to aluminium chloride and subsequently reduced the chloride to the metallic state by means of sodium (replacing the potassium used by F. Wohler because of its small equivalent—sodium 23 and potassium 39—and the cheapness of sodium salts). This was sold at the rate of £54 per lb., whilst in 1924 it is roughly 1s. 1d. per lb.

Ross Method.

In the year 1856 the Tessier Brothers established a factory in Amfreville, near Rouen, where a process recommended by Dr. Percy and H. Rose was used, which depended on the reduction of cryolite by sodium. Unfortunately, the metal obtained was impure. It is believed the Ross process was used in the first aluminium works in England; this enterprise started in 1859 at Battersea, London, and later moved to Newcastle-on-Tyne.

Castner and Netto Methods.

These methods were employed by the Aluminium Company, Limited, of Birmingham, embodied substantial improvements, and continued to be the principal source of the metal until the successful application of electricity entirely replaced the chemical methods.

The process depends upon the production of aluminium-sodium double chloride by passing chlorine over a mixture of clay, carbon and common salt contained in a horizontal retort—the mixture is dephlegmated in the apparatus before passing the chlorine, the aluminium sodium chloride is condensed in a brick receptacle. The chloride is mixed with cryolite in the proportion of 2: 1 and small pieces of sodium, and heated in a rotating cylindrical air-furnace at the temperature of reaction.

ELECTRO CHEMICAL METHODS OF PRODUCTION.

Only after a considerable number of years, during which the application of electricity to metallurgy seemed to have passed entirely into oblivion, did the brothers Cowles in 1884 produce a process for the manufacture of aluminium where electrical energy was utilised and a type of apparatus which is styled the electric furnace—this achievement

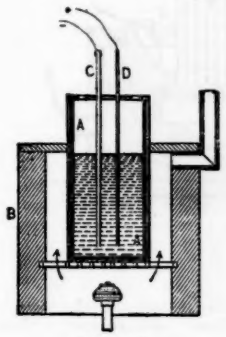

FIG. 2A.

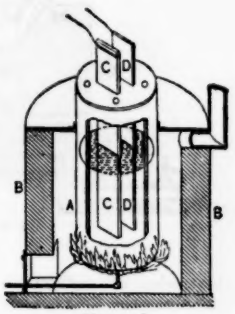

FIG. 2B.

was rightly considered to be the first great advance in electro-metallurgy.

The method was used fairly successfully employed in making alloys of aluminium with copper. The following principle was made use of in the Cowles' process. A powerful electric current was interrupted, the terminals being large carbon rods, and the furnace charged with corundum, carbon and the metal to be alloyed; the charge was subject to intense heat for about five hours, when the alumina was reduced to aluminium which combined with the metal while the oxygen escaped as carbon monoxide. Fig. 1 shows a vertical section of a Cowles' electric furnace. Built below the floor line, it is lined with fire bricks, and is usually about 5 ft. long, 3 ft. deep and 20 in. wide—internal dimensions. The two electrodes (slightly inclined) are built in cast-iron tubes. Near the outer end of the electrode rods are clamps, easily removable, through which passes a screw having a "T" handle at its outer end, whilst a wooden block rests against its inner end. The rotation of this screw moves the electrode inwards or outwards. Iron plates protect the brickwork of the furnace. In the cover is a hole through which the gases issue as they are driven off by the heat during the reaction. The ore employed was sometimes corundum, a variety of Al_2O_3, but in England bauxite was used. Two pieces of sheet iron connected by a distance piece are placed on either side of the electrodes, thereby preventing the charges from spreading laterally during insertion. The ends of the furnace are filled in with charcoal and the lids are luted on with clay. A high current is passed through, which is gradually increased as the resistance decreases, owing to the fusing of the charge and the electrodes, and the electrodes are drawn further apart. The reduction takes about one and three-quarter hours.

Hall's Method.

An electrolytic method, the invention of Chas. M. Hall, was patented in 1886 and proved of considerable commercial value, since the aluminium he produced was remarkably cheap as compared with the existing prices of that period. Guaranteed 98 per cent. pure, he sold at about 18s. 6d. per lb., the lowest figure the metal had ever touched, but in November, 1889, the price was further reduced to 8s., for which achievement Mr. Hall was heartily congratulated. His pro-

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cess was to dissolve alumina in the form of bauxite in a fluid bath of double chloride of potassium and aluminium, and to electrolyse it, using an anode of non-carbonaceous material. Copper was used as anode and carbon as cathode. The reduction was carried on at a low red heat. It will be noticed that in this process alumina is dissolved in a suitable solvent and electrolysed without the decomposition of the solvent used. Hall constructed a number of types of apparatus, but the types in Figs. 2A and 2B proved the most efficient. They represent the vertical section (Fig. 2A) and complete view of furnace (Fig. 2B). C and D are

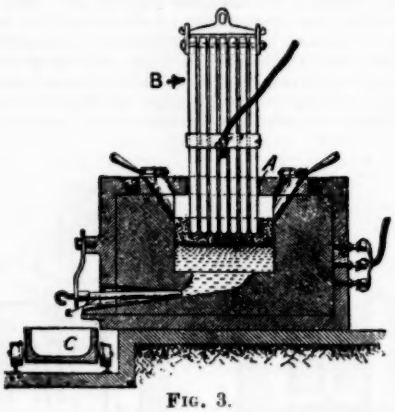

Fig. 3.

electrodes of carbon in the vessel A, A, which contains the clay or steel electrolyte. The vessel A, A is lined within with a layer of carbonaceous material, which protects the sides of the vessel against the corroding action of the molten aluminium. B, B represents the brickwork for the walls of the furnace made of highly refractory material. The pots used were 24 in. × 16 in. × 20 in., and took a charge of 300 lbs., when nearly the whole of this aluminium is reduced in one operation.

Heroult's Method.

The experiments of P. Héroult were concerned with practically all the departments of electro-metallurgy. During the ten years of his investigation he designed and constructed many types of furnaces, added manifold modifications, and finally brought his furnace to a fine state of perfection. Although the process of Cowles was undoubtedly the first in the field, the Héroult was the more economical and practical in commercial application. The following electrothermic process was introduced in 1888, and depended upon the decomposition of aluminium-sodium double fluoride (cryolite), without the addition of a salt of the alkaline earths or alkalis. During the electrolysis operation of the alumina salt, anhydrous alumina mixed with cryolite was added to replace the reduced salt.

In Fig. 3 the apparatus used in this method is shown. A rectangular iron box A, about 8 ft. by 6 ft., internal dimensions, constitutes the electrolytic cell. The cell is connected with an electric generator, and is necessarily made the cathode. A number of carbon rods B (about 48, 3 in. dia. and 15 in. long) are in suspended copper holders arranged in rows which act as anodes, these being connected to the other generator pole. The resistance of the electrolyte generates sufficient heat to keep the mass fluid; the molten metal sinks to the base of the cell, and is tapped at intervals into the receiving vessel C. To form copper alloys the metal is melted as usual with a voltaic arc, the anode being a movable carbon rod, and copper serves as the cathode. When the Cu is melted the alumina is introduced, and is soon liquefied and decomposed, the alloy formed being tapped from the bottom of the cell as before. The oxygen evolved at the cathode either forms carbon monoxide, which burns to the dioxide on the surface, or escapes as gas. The process is continuous. For a crucible 8 in. deep by 5 in. inside dia., with a carbon anode 2 in. dia., a current of 400 amperes with an electromotive force of 20 to 25 volts was used. An amperemeter introduced into the circuit indicates the progress of the operation and the necessity for tapping or adding fresh supplies of bauxite.

Numerous patents by C. S. Bradley, I. B. Hall, Berg, Bull, Lossier and many others, embodying ideas more or less valuable, tend to establish the electrolytic process as the cheapest, most efficient and practical method for the preparation of aluminium, and it may be said that the electro-metallurgy of aluminium has already attained a state of perfection beyond which no great advance can be anticipated.

Purification of Bauxite and Cryolite before Reduction.

The first step in the production of aluminium therefore consists in the purification of natural ore by chemical methods. Since native bauxite and cryolite are generally found contaminated with impurities such as iron and silica, etc., a preliminary purification is effected when most of the injurious impurities of the ore are separated as oxides, and the fairly pure alumina obtained passes on to the reduction process. The extraction of the impurities on a commercial scale is generally carried out in the following manner. The native bauxite or cryolite is roasted at a low temperature to convert the ferrous oxide into ferric oxide; moisture is driven off and organic matter is decomposed and escapes into the atmosphere as gas or is converted into oxides, or sulphide, etc., remaining contaminated with the alumina, but is removed at a later stage of purification. The mass is then removed to iron kettles and digested with sodium hydrate solution under pressure, whence all the alumina moves into solution with the sodium hydroxide, and all the impurities (deleterious to the physical and mechanical properties of the virgin aluminium) remain as a precipitate in suspension in the liquid.

$$Al(OH)_3 + 3NaOH = Al(ONa)_3 + 3H_2O.$$

The suspended matter is filtered off by decantation, generally, or through a modern commercial filter, and the filtrate is treated for alumina by a reduction process such as used by C. I. Bayer (1897), namely, a little aluminium hydroxide is added to the solution, which is agitated, when the aluminium hydroxide separates out from the solution until the ratio $Al_2O_3 : Na_2O$ is about 1:6. The precipitation of the aluminium hydroxide can

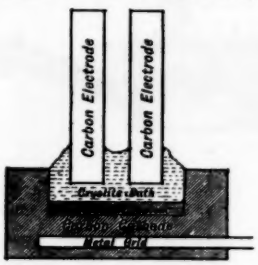

Fig. 4.—Electric Furnace for the Reduction of Aluminium.

be also effected by passing carbon dioxide through the solution:—

$$2Al(ONa)_3 + 3CO_2 + 3H_2O = 2Al(OH)_3 + 3Na_2CO_3.$$

The precipitate, which is filtered off, dried, and heated, is now in a fairly pure condition for the subsequent reduction processes to the metallic state. In a series of lectures by Dr. Rosenhain at the Royal Society of Arts, the author mentions that recently a process, for which a very great economy is claimed, has been put forward. In this a mixture of bauxite with carbon is heated in an atmosphere of nitrogen to a temperature of from 1,000 to 1,800 deg. C.; as a result aluminium nitride is formed. Subsequent treatment of this nitride with soda yields ammonia and sodium aluminate. The ammonia thus produced is of course a valuable by-product, and it is said that alumina produced in this way is very cheap, costing about half the outlay of the Bayer process.

Electric Reduction of Purified Bauxite and Cryolite.

The final product of the purification of bauxite or cryolite serves as the raw material for subsequent reduction to aluminium metal. However,

since the melting point of pure alumina is very high, an artificial product corresponding to the formula Al_2F_4NaF is often used (M.P. 1,000 deg. C.). The addition of 5 per cent. of pure alumina to this product lowers the melting point to 915 deg. C., and a fused mass of this strength is generally employed in the electrolytic reduction process.

The diagram, Fig. 4, shows a diagrammatic view of the form of electric furnace used for the reduction; the current serves a dual purpose—firstly, produces the deposition of metallic aluminium, and secondly, maintains the proper temperature to keep the material molten. An electrode in the form of a metal grid is secured in a carbon block to which is connected a cable carrying the current. The block is recessed out and contains the molten cryolite, into which are suspended vertical carbon electrodes to which are attached cables carrying current to complete the circuit. The furnace works at a temperature of about 950 deg. C., with a voltage between 6½ to 7½, a battery of furnaces being connected together in series. The production works out at approximately 1 kilogramme for 25 kilo-watt hours.

For the production of very pure aluminium many difficulties have to be overcome; the electrodes must be of a high degree of purity, and great care must be exercised by the workmen to avoid the risk of contaminating the metal by the process tools and foreign elements lying near the apparatus. When sufficient metal has collected at the base of the furnace they are tapped and the metal is run off first into large crucibles and then into smaller ingots.

Since a certain amount of foreign matter is liable to be included with these ingots, it is necessary to subject the metal to a re-melting and re-cleaning operation. The metal is then cast into ingots, which are sold on the market and known as "notched bars." The metal produced by commercial processes always contains silicon and iron. No aluminium, unless chemically prepared, can be produced which does not contain these constituents. The following is a good sample of commercial aluminium: Aluminium, 99.59; silicon, 0.23; and iron, 0.18 per cent.

IN CONNECTION with the sliding-scale dispute in the steel trade at Rotherham, notices to cease work at three large works expired last Monday. The works affected are Messrs. Steel, Peech & Tozer, Limited, Rotherham; the Park Gate Iron & Steel Company, Limited, Rotherham; and Messrs. Samuel Fox & Company, Limited, Stocksbridge. Skilled men are resisting a request by the employers to change from the district rate of wages to the sliding-scale arrangement; and the semi-skilled men and labourers are asking to be put on the district rate, instead of the sliding scale, as at present. The members of the Iron and Steel Trades Confederation, who work under the sliding scale, are not taking part in the dispute, as the sliding scale is not objected to by them. The total number of men directly involved is said to be over 6,000.

E. N. MACKLEY & COMPANY are building a new pattern-shop at their Hawkes Road Works, Gateshead. Provision has also been made for building an additional erecting shop, the present shop being very congested. Modifications are being made alike to the iron and brass foundries in order to increase the output capacity. At the present time the works turn out iron castings up to 5 tons in weight and brass castings up to 1 ton. In the erecting shop a new test bed has been laid down. The motors are designed to give up to 260 b.h.p. and any speed from 700 to 1,600 r.p.m. To ensure accuracy of testing facilities the motor builders have supplied curves for all speeds and powers between these limits. The sump is a tank of 10,000 galls. capacity, whilst the discharge tank, which is provided with both V and rectangular notches, has a capacity of 3,000 galls. Of the pumps passing through the works at the time of our representative's visit, mention may be made of one designed to deliver 800 galls. per min. against a head of 940 ft. when running at 1,170 r.p.m. Of particular interest, however, is a 12-stage pump, which at 1,170 r.p.m. is to deliver 600 galls. per min., against a head of 1,500 ft. We believe that this is the heaviest duty for which a single unit, running at so low a speed, has ever been built. In the Mackley pump it is rendered possible by the patented method of step boring the casing and the patented method of assembly.

Fluxes in the Tinplate Industry.*

BY T. LEWIS BAILEY, PH.D., F.I.C.

[ABSTRACT.]

The present method, which dates from the later part of last century, is as follows:—

The pickled and washed sheets are passed wet through a 3-in. or 4-in. layer of a strong neutral solution of zinc chloride into the molten tin on which the zinc chloride floats. Emerging from the tinning pot (they are carried along by mechanical means) the sheets pass upwards through a series of rolls working in the "grease pot," which is filled with molten palm oil; the pressure of the rolls removes the surplus tin, the primary object of the hot palm oil being apparently to keep the tin coating in a condition to allow of such removal.

The iron sheets at the moment of their introduction into the molten tin must be dry, free from oxide and at any rate not cold. The pickled sheets are kept covered with water right up to the moment when they can be transferred to the tinning operations, so that a wet sheet is to be dealt with.

On the introduction of the mechanical tinning process, with its squeezing rolls and the preliminary use of zinc chloride in place of palm oil, satisfactory tinplates were produced which bore a considerably lighter coating of tin than was usual by the older method. The zinc chloride would appear to have some specific action in addition to the functions mentioned above when writing of palm oil.

G. E. Duckering, in a Home Office Report on the Tinning of Metals, published in 1907, says:—

"Apparently the indispensable quality of a flux is the property of fusing at a temperature lower than the fusing point of the coating metal. In other words, a flux will only act as such when in the liquid state. Generally speaking the chlorides constitute the best fluxes. . . The exact function of fluxes appears to be very little understood and references on this point are very meagre, being usually confined to the statement that they cause the metal to run and prevent oxidation. Whatever their real action, however, there can be no doubt that they greatly modify the effect of surface tension in the coating metal, and in some way render the conditions favourable for union of the coating metal with the metal to be coated."

To continue: the zinc chloride is put on to the surface of the tin in the tinning bath in the form of a strong solution, which is in a state of continuous ebullition; its temperature, according to observations made in 1891 by Atfield, being usually about 200 deg. C. or a little above this.

Some years ago, by means of papers which had been soaked in metanil yellow (dolly cream), the author found evidence of traces of free hydrochloric acid above tinning baths, the papers assuming slowly a violet colour when held some distance above the bath: the fume appeared to contain also traces of tin compounds.

The "scruff" (skimmings from the flux box and the succeeding portion of the tinning bath) is a most complex mixture containing zinc chloride, palm oil, metallic tin, sulphide of iron, etc.

Interesting as they are, however, the above observations do not carry one very far in an attempt to elucidate the rationale of the action of zinc chloride as a flux.

The manufacture of terneplate (coating with a lead-tin alloy) follows much the same lines as that of tinplate proper in its mechanical details. Zinc chloride is used as flux, as in the case of tinplate, but resin takes the place of palm oil.

MESSRS. JOHN THOMPSON WATER TUBE BOILERS, LIMITED, in consequence of increasing business, particularly in connection with their vertical straight tube-type, water-tube boilers, have transferred their head office from Wolverhampton to Imperial House, Kingsway, London, W.C.2.

* A Paper read before a joint Meeting of the Faraday Society, the Institute of British Foundrymen and the Institute of Metals.

XUM

Improvements in Stoppered Ladles.

Every steel foundryman has encountered the inconveniences which arise through defects occurring when casting either ingots or castings by means of the ordinary type of stoppered ladle. These irregularities are intensified when the steel to be poured is not sufficiently hot. Trouble may also be experienced in pouring when the ladle or stopper-rod are not sufficiently heated.

The troubles resulting from too low a bath temperature are of quite a natural order; the steel is inert and cannot flow properly. The bottom and walls of the ladle become crusted up, while there is also a tendency for "tears" to form at the outlet of the ladle.

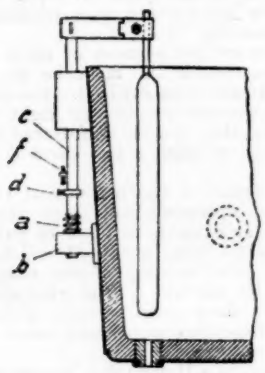

FIG. 1.

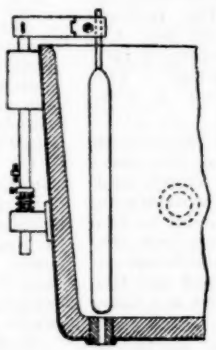

FIG. 2.

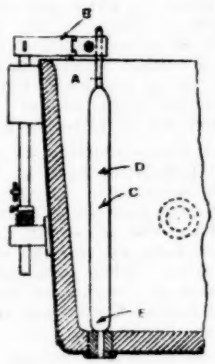

FIG. 3.

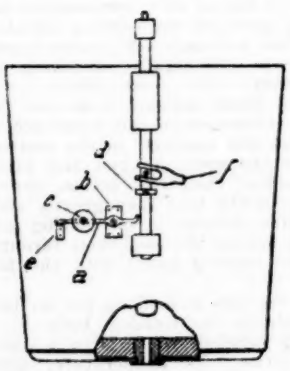

FIG. 4.

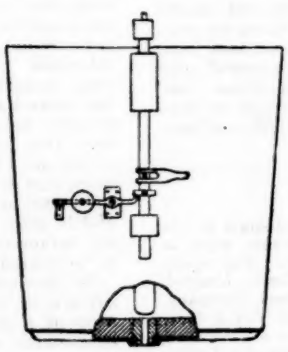

FIG. 5.

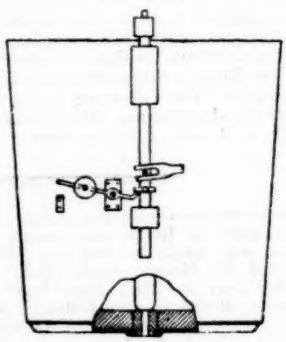

FIG. 6.

This incrustation causes deformation in the shape of the stopper end. The seating surface formed by the nozzle, and which is more or less firm and dry, becomes more or less "doughy" and sticky, due to the presence of the incrusted deposits, and this tends to raise the level of the seating. If now the stopper rod is closed in the usual way, the stopper end is forced, by suction, on to the sticky seat, where it adheres firmly or is welded on. The extent to which the stopper adheres depends on the consistency and thickness of the deposit referred to above, and on the expulsive force of the stopper end when it drops or closes. It is often a matter of luck whether the rod can be lifted or whether it remains stuck.

A new invention, described in a recent number of "Die Giesserei," and patented in Germany and America, seeks to overcome the sticking of the stopper-rod, no matter what the temperature or other condition of the bath may be at a given moment.

The innovation can be carried out in three different ways. In Figs. 1, 2, and 3, showing one method of applying the patent, the buffering device consists of a powerful steel spiral *a*, placed above the bearing *b*, and embracing the rod *c*, and a positional ring *d* placed above the spiral spring and held in position on the slide rod by means of a straight-through bolt and nut or a locking screw.

Figs. 4, 5, and 6 show another arrangement of the buffer. This consists of a two-armed lever *a*, held on the bearing plate *b*, fitted with an adjustable counterweight *c*, together with the positional ring *d* and the stop *e*.

Suppose now that the stopper-rod is closed, the impulsive force of the same on its downward travel is gently absorbed, before the stopper reaches its seat, by the positional ring or stop on the slide-rod striking the spiral spring resting on *b*, or by means of the free lever-arm (in the second arrangement). The final closing movement of the stopper is effected either by its own gravity, or with the help of the workman, who presses the lever *f*, and so overcomes the resistance of the buffer spring.

Figs. 1 and 4 show the stopper-rod in the wide open position; Figs. 2 and 5 show the position shortly before the stopper is seated; and in Figs. 3 and 6 the stopper-rod is in the closed position.

The effect of the new device in overcoming the difficulties referred to above is that it enables the stopper-rod to bed down without any undue force. With the force exerted in existing stoppers, and even where the bath temperature is high, the stopper may easily cake on to the nozzle and stick fast. Furthermore, the force of the stopper-rod is liable to set up distortion, and possibly lead to the stopper being fused off.

Recent developments in the Canadian iron and steel industry indicate that improvement, although very slow, is steady. Operations have been increased in some directions, while shutdowns are rare.

The Canadian Press states that Mr. Charles M. Schwab, President of the Bethlehem Steel Corporation, is in negotiation for the acquisition of the assets of the British-American Nickel Corporation, which recently went into liquidation. The plants at Deschenes and Sudbury have been closed, and 1,500 men are out of employment pending new arrangements as to ownership.

It is reported at Sault Ste. Marie (Ontario) that active development is about to continue on the iron claims in the Michipicoton district on a large scale. Two thousand feet of trenching and a number of shallow pits have disclosed an extensive deposit of hematite iron ore similar in quality to that of the old Helen mine that was operated for many years by the Algoma Steel Company.

the recent stiffening of Continental rates of exchange [illegible]

Trade Talk.

THE CARLTON IRONWORKS, of Messrs. Dorman, Long & Company, are likely to blow out in the near future a blast-furnace at present making ferro-manganese.

SIMONDS SAWS, LIMITED, have moved from 53a, Bayham Street, Camden Town, London, N.W., to Fulwood House, Fulwood Place, High Holborn, London, W.C.

MESSRS. WILLIAM SIMONS & COMPANY, LIMITED, shipbuilders, Renfrew, are to build to the order of the Glasgow Corporation a new sludge steamer at a cost of over £48,000.

A FIRE broke out last Saturday night at the engineering works of Messrs. George Crossley, Limited, at Cleckheaton. The pattern shop and drawing office, a two-storey block, was totally destroyed.

MESSRS. DORMAN, LONG & COMPANY, LIMITED, have decided to blow in a new furnace at their Warrenby Ironworks. The new furnace is one of the latest type, and will give a greatly improved output.

A REDUCTION in the duty on certain fine-grade steel imports has been granted by Spain to Great Britain. This concession is similar to that accorded by Spain to Germany under the terms of the agreement between the two countries.

CLYDE SHIPBUILDERS and other important industrial concerns are viewing with anxiety a proposal to increase Clydebank municipal rates by 25 per cent., which practically means an assessment of no less than 22s. in the £.

AN EXTRAORDINARY general meeting of Stewarts & Lloyds, Limited, held at Glasgow recently, passed resolutions for increasing the share capital of the company to £6,800,000 by the creation of 2,700,000 new deferred shares of £1 each.

MESSRS. ARMSTRONG, WHITWORTH & COMPANY, LIMITED, have booked an order for a gunboat for the Siamese Government. The vessel is to be completed within a year. This firm has also received a further order, for locomotives for the Nigerian Railways.

A SCHEME SUBMITTED by R. Dempster & Son, Limited, Huddersfield Road, Elland, for the installation of horizontal retorts at Tradeston Gas Works, has been recommended for acceptance to the Glasgow Town Council. It is understood the cost will amount to approximately £51,700.

MESSRS. THE VICTAULIC COMPANY, LIMITED, 28, Victoria Street, London, S.W.1, inform us that after August 23, 1924, the registered offices of the company will be at King's Buildings, Dean Stanley Street, Westminster, S.W.1. The telegraphic address will then be changed to "Victaulic Parl," London.

THE LATEST MONTHLY ascertainment price of Cumberland hematite pig-iron, mixed numbers, is £4 17s. 10.94d. per ton, a decrease of 1s. 1.74d. per ton compared with the previous month. In consequence, the wages of Cumberland iron-ore miners will be reduced by from ½d. to 1d. per day (¼d. a day in the case of boys under 16).

MESSRS. LITHGOW, LIMITED, Port-Glasgow, last week launched the cargo steamer "Bellailsa," of 7,800 tons deadweight carrying capacity, which they have built for British owners. The principal dimensions of the vessel are:—Length, 400 ft.; breadth, 52 ft.; and depth, 29 ft. The ship is being engined by Messrs. J. G. Kincaid & Company, Greenock.

MESSRS. WM. BEARDMORE & COMPANY, LIMITED, Parkhead Steelworks, Glasgow, have secured an order for a steam accumulator from Messrs. Ruths' Steam Accumulator Company, Limited, 47, Kingsway, W.C. This will be the first of its kind to be made in this country, and is for shipment to Newfoundland in connection with the paper-manufacturing industry.

MESSRS. GUEST, KEEN & NETTLEFOLDS are establishing a screw-making factory in Australia. A site for the factory has been purchased at Sunshine, near Melbourne, and an adequate supply of electric power will be available from the State Electricity Commission's works at Yallourn. It is considered that an excellent product for the Australian market can be manufactured in Australia.

MESSRS. GRAZIANI & COMPANY, LIMITED, 110, Fenchurch Street, London, E.C.3, state that they have been appointed general agents in this country for Messrs. Ansaldo, S.A., engineers and shipbuilders, of Genoa, Italy, who have taken over the works formerly belonging to Messrs. Gio. Ansaldo & Company, the largest engineering and shipbuilding undertaking in Italy.

THE shipment from Newcastle-on-Tyne to Chicago of the 50,000-kw. turbo-alternator (a model of which is on view at Messrs. Parsons' stand at the Wembley Exhibition), to the order of the Commonwealth Edison Company, of that city, and manufactured for the most part by Messrs. C. A. Parsons & Company, Limited, of Newcastle, is a big undertaking. The plant, of course, is being dealt with piecemeal, and one of the parts weighs 79 tons. The remainder includes 113 cases of under 5 tons, 27 between 5 and 10, 8 between 10 and 15, 4 between 15 and 20, 5 between 20 and 30, one weighs 40, another 42, another 43, one upwards of 60 tons. The aggregate weight is 1,200 tons. The plant will not travel by rail either in this country or in the United States. Consigned to Messrs. Sheldon, in Chicago, for use in the generating of electricity, it is the third of the kind in use there, although it is the first of English manufacture. The turbo-alternator is to be transhipped at Sorel, Quebec, into a steamer specially chartered, by name the "John Gehm." This vessel is specially constructed for passage through the Welland Canal. Part of it will be discharged at Fisk Street Station of the Commonwealth Edison Company, and the larger portion will be taken up the branch canal through Lake Michigan, a special dock having been built at the Crawford Avenue power station for its reception. Messrs. Parsons are sending their own men out with the consignment, and at Sorel they will be met by the Chicago representative of Messrs. Sheldon. It is interesting to note that in order to transport the turbo-alternator from Parsons to the North-Eastern Marine Engineering Company's wharf at Wallsend-on-Tyne it was necessary to block the London and North-Eastern Railway Company's line last Sunday and the Sunday previous. By this means all but the two largest packages are being conveyed; in their case it is impossible to use the railway because of the weight and dimensions.

Personal.

MR. J. F. BELL has been elected president of the Institution of Gas Engineers for the ensuing year.

MR. S. C. LAWS, M.A., M.Sc., the Principal of the Wigan Mining and Technical College, has accepted the Principalship of the Northampton Institute, Clerkenwell, London.

MR. W. W. WOOD, of Sandygate Lodge, Sheffield, has been elected Master Cutler in succession to Mr. James Neill. Mr. Wood is the sole active partner in the Wardsend Steel Works.

Wills.

JENKS, H. F. W., Wolverhampton, iron and steel merchant	£11,162
DARLING, A., of Darling & Sellers, machine tool makers, Keighley	£12,036

Patent Specifications.

Particulars of complete specifications accepted, furnished by Mr. Eric Potter, Patent Agent, of Lonsdale Chambers, 27, Chancery Lane, London, W.C.2. Printed copies of the specifications in the following list are now on sale.

219,346. BRITISH ALUMINIUM COMPANY, LIMITED. GWYER, A. G. C., AND PHILLIPS, H. W. L. Aluminium alloys. Jan. 22, 1923.

219,482. TALBOT, B. Coating of iron and steel with concrete pitch, etc. July 14, 1923.

203,688. SOCIETIE ANNON METALLURGIQUE D'AUBRIVES ET VILLERUPT. Control of pouring in metal-casting machines. Sept. 5, 1922.

219,539. BAKER, H. Annealing pans. Oct. 6, 1923.

219,753. CHEMISCHE FABRIEK GRIESHEIM-ELEKTRON. Method of casting magnesium or magnesium alloys. May 4, 1923. Addition to 187,943.

Gazette.

THE WIDNES FOUNDRY COMPANY, LIMITED, is being wound up voluntarily, with Mr. S. S. Dawson, 51, North John Street, Liverpool, as liquidator.

THE ELLARRKOSE STEEL COMPANY, LIMITED, is being wound up voluntarily. Mr. D. W. Ackery, of 70, Commercial Road, Portsmouth, has been appointed liquidator.

THE LAST DAY for receiving proofs in connection with a dividend to be paid by the Provincial Lighting and Engineering Company, 369, Eccles New Road, Weaste, is August 30.

Obituary.

MR. ROBERT DOUGAL, ironfounder, died at Wellsyde, Bathgate, last Sunday.

MR. ALFRED HALL, late of Heaton Park, and for many years with Joseph Robinson & Son, ironworks, Salford, died at Ansdell last Saturday.

MR. WALTER JONES, of Messrs. Jones & Attwood, heating engineers and ironfounders, died at Stourbridge last Monday. He was a past president of the Institution of Heating and Ventilating Engineers, and of the Staffordshire Iron and Steel Institute.

XUM

IRON AND STEEL MARKETS.

Pig-iron.

MIDDLESBROUGH.—The extended holiday period in Tees-side industries, traditional in this district, has, of course, meant a complete suspension of market operations over the last half of the month, and consequently little business of importance can be expected until the restarting of works early in September. In the meantime the outlook is regarded by ironmasters as more hopeful, the conclusion of the London Conference having inspired a better feeling in trade circles, and the expectation is now entertained that, confidence being restored, there may be an early revival of more active market conditions. That, of course, will not be achieved in a moment, and optimism is restrained by the fear of intensified competition from a restored Germany. The latter has solid advantages in the longer hours and low wages of the German workers, and it is not yet apparent how British producers can meet the challenge. The 26 per cent. reparation levy only protects the home market, and leaves the menace of German competition in neutral markets, untouched. Consequent upon the closing of the markets prices remain practically stationary, makers of No. 3 G.M.B. holding out for 84s., although possibly that could be shaded. No. 1 is not very plentiful, and commands 89s., No. 4 foundry 83s., and No. 4 forge 82s.

The East Coast hematite trade is still quite lifeless. There is very little inquiry, and such as there is seldom fails to mature. However, whilst quoting 93s. for mixed numbers in small parcels, makers are selling at 92s. 6d. for fair quantities, and the premium for No. 1 quality is only 6d. per ton. On the North-West Coast prices are maintained, with Bessemer mixed numbers at 105s. per ton, delivered at Glasgow; 110s. per ton delivered at Sheffield; and 115s. per ton delivered at Birmingham.

LANCASHIRE.—In the absence of even a limited demand on the part of the local foundry consumers business in Midland pig-iron continues depressed, with prices weak and irregular. The nominal price for Midland No. 3 foundry iron delivered in Manchester is 95s. per ton, and for small lots for immediate delivery this price is being paid; but it is quite impossible to sell large parcels for delivery over the remainder of the year at this price, or at anything near it. Derbyshire, Lincolnshire and Northamptonshire foundry irons have been sold in Manchester at from 2s. to 2s. 6d. per ton below the regular ostensible price, and, in spite of the high rate of carriage, even Cleveland iron can come into this market at 95s. per ton.

THE MIDLANDS.—Business on 'Change at Birmingham of late has been quite uneventful, consumers, on the whole, confining purchases to the minimum of actual requirements. The trade in foundry grades, however, is more encouraging, but even this quality iron has fallen to very lean prices which leave little or no profit. Quotations: Northamptonshire No. 3 foundry, 81s. 6d. to 82s. 6d.; Derbyshire No. 3, 86s. to 87s. 6d., all net f.o.t. stations.

SCOTLAND.—Notwithstanding the more encouraging outlook in the political situation, there is as yet no improvement to report in the state of the Scottish pig-iron market. It is true there has been a shade more inquiry, but there is no increase in the volume of business passing. The price of No. 3 foundry continues easy at 92s. 6d. per ton f.o.t. furnaces. Inquiries from abroad have been a shade more frequent, but there has been no increase in the actual volume of business placed.

Finished Iron.

Manufacturers of almost all descriptions of finished materials report business as very depressed, and many works in South Staffordshire are only operating on a partial scale, while some are entirely closed down. The explanation, of course, is the displacement of iron by cheap foreign steel, and the difference in price is too great to permit any possibility of competition. Some of the works only continue in operation because it is calculated that more money would be lost if they were closed. It is a lamentable state of affairs. Quotations: Marked bars, £15 (net f.o.t. makers' works); crown bars, £13; nut and bolt bars, £12; gas strip, £13 5s., all net delivered Birmingham area.

Steel.

So far, conditions in the steel trade evidence little sign of improvement, with business both in the home and export markets quiet and without features of interest. At Sheffield the refusal to accept the sliding scale proposed by the employers has resulted in a strike of about 7,000 workers in the trade, and a further blow is thus aimed at the recovery of the city's principal industry. There is only a poor inquiry for billets, and prices are not very firmly held. The price of ferro-manganese has been further reduced by 10s., bringing the price for the home trade down to £13 per ton. Quotations for export are purely nominal. There is no change to report in the condition of the tinplate market, which continues quiet. The volume of business has not been large, and prices are firm.

Scrap.

Reports from the various centres of the scrap metal trade are far from encouraging, and from all accounts the prospect of an early revival must be regarded as remote. In Lancashire the foundry trade is still short of work, and there is not much demand now for cast scrap. Dealers usually quote 85s. per ton delivered for good broken machinery iron, but it is doubtful whether much can be sold at this price, and since it became the usual quotation foundry pig-iron has experienced a further drop in values. In Scotland, also, demand is restricted, with machinery cast-iron scrap weak, quantities being now available at 90s. to 92s. 6d. per ton. Ordinary cast-iron scrap, in handy pieces, suitable for foundries, can be had at 83s. 6d. to 85s. per ton, and for larger material suitable for steelworks, 82s. 6d. per ton. There is not much of the latter being offered. Light cast-iron scrap is 72s. 6d. to 75s. per ton, and if mixed with firebars 2s. 6d. per ton less. The above prices are all per ton, delivered f.o.t. consumers' works.

Metals.

Copper.—Movements in standard metal during the current week, on the whole, have evidenced a steady tendency, fluctuations in values indicating a narrow range of quotations day-by-day. The successful conclusion of the London Conference, however, may be expected to have a reassuring effect on markets, the inference being that, with the settlement of the political position there should shortly follow a very increased consumptive demand for the metal both at home and in the Continental industries. Current quotations:—*Cash*: Thursday, £63 5s.; Friday, £63 10s.; Monday, £63 2s. 6d.; Tuesday, £62 12s. 6d.; Wednesday, £63 2s. 6d.

Three Months: Thursday, £64 5s.; Friday, £64 10s.; Monday, £64; Tuesday, £63 12s. 6d.; Wednesday, £64.

Tin.—Although temporarily checked in consumptive demand, due mainly to seasonal causes, the high scale of values recently established in standard tin continues almost undiminished, while substantial American buying orders have also contributed a stabilising effect in the market for this metal. Dealers for some time past have mostly supported the market in anticipation of American buying, and this having ensued to a great extent against requirements into the early autumn, the view is held that, although the American demand has been fairly well satisfied for the moment, buying may be resumed largely before very long in order to make provision for increased needs later on. Current quotations.—*Cash*: Thursday, £259 15s.; Friday, £257 10s.; Monday, £254 5s.; Tuesday, £250 15s.; Wednesday, £253.

Three Months: Thursday, £260 15s.; Friday, £258 10s.; Monday, £255 2s. 6d.; Tuesday, £251 15s.; Wednesday, £254.

Spelter.—Business in this section of the metal markets continues steady, with values firm, and although buying is at the moment comparatively slow, smelters are fairly optimistic as regards the future. Exports of galvanised sheets were over 6,000 tons higher last month than in June. Current quotations:—*Ordinary*: Thursday, £33 1s. 3d.; Friday, £32 18s. 9d.; Monday, £32 15s.; Tuesday, £32 12s. 6d.; Wednesday, £32 13s. 9d.

Lead.—The conclusion of the builders' strike may be expected to have a stimulating effect upon the market for soft foreign pig, although, so far, conditions have undergone little material change from those previously reported. Shipments of lead from Australia to this country in July amounted to 8,808 tons, as against 8,147 tons in June and 5,050 tons in May. Current quotations.—*Soft foreign (prompt)*: Thursday, £33; Friday, £32 17s. 6d.; Monday, £33; Tuesday, £32 10s.; Wednesday, £32 15s.

The managers, foremen and clerical staff of the British Chilled Roll and Engineering Company, Limited, of Haverton Hill, Middlesbrough, took advantage of the local general holiday to spend a few days at the British Empire Exhibition, at Wembley. The excursion was organised by Mr. S. V. Toy, the steel foundry manager.

The recent stiffening of Continental rates of exchange [illegible] 10s.